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SCHOOL SCIENCE AND MATHEMATICS

OCTOBER 1946

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

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Contents of previous issues may be found in the Educational Index to Periodicals.

Consider what nation it is whereof ye are; a nation not slow and dull, but of a quick, ingenious and piercing spirit, acute to invent, subtle and sinuous to discourse, not beyond the reach of any point the highest that human capacity can soar to.—From DETROIT PUBLIC LIBRARY.

CONTENTS FOR OCTOBER, 1946

SCHOOL SCIENCE AND MATHEMATICS

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COME THANKSGIVING TIME

Unique among organizations of modern affiliations of teachers is the Central Association of Science and Mathematics Teachers, Incorporated. It has grown from interest in the fundamental relationship that exists between phenomena of science and mathematics and the impact of this relationship upon the patterns of human behavior. A feeling which has long pervaded members and friends of that organization was again put into words at the May 11th CASMT board of directors meeting at the Book-Cadillac Hotel. That time it was Fred Moore, of Owosso High School, the cogent scholar and teacher, who called attention to the soothing satisfying spirit that comes with the conducments of that organization. He testified forcibly that the contributions of the journal, SCHOOL SCIENCE AND MATHEMATICS, and of the programs and fellowship at the annual convention have had direct practical and challenging effects upon his own teaching experiences in the classroom. Notwithstanding the down to earth functional nature of CASMT, its members are not to be found in any rut. A glance at any part of the roster reveals readily the names of persons representing eminence in various branches of life activities. Membership and participation in CASMT activities are not known to alienate from any of the dynamic modes of life.

THE 1946 CONVENTION

The November 29 and 30, 1946, convention program has brought enthusiastic expression and appreciative respect from each and every person learning of the details from the local arrangements point of view.

EXHIBITS

The exhibits, overflowing the Italian Garden, the wares of publishers and apparatus manufacturers, appeal to the veteran and the naive in the conventioner alike. They are displays and demonstrations of school materials, equipment, and activities that are of special interest and value to teachers. The initiated know that CASMT convention exhibits offer educational values and practical help equal to any other features of conventions anywhere. Accordingly, it is wise to plan sufficient time for careful examination of the many exhibits.

MEETINGS

The program fairly speaks for itself,—as the reader proceeds, involuntary introspection is a beneceptive response. NEW POWER, PRODUCTS,

AND PERSONNEL, the theme of the convention, is unfolded from the start as Gerald Wendt, editorial director of *Science Illustrated* delivers the opening address. Two other prominent speakers, already scheduled, will be announced soon in releases from CASMT offices. Awarding of emeritus membership status, by George K. Peterson, of North High School, Sheboygan, Wisconsin, will conclude the first session.

Then luncheon in the Crystal Ball Room followed by a most satisfying entertaining lecture-demonstration. Entitled "Previews of Progress," this General Motors Corporation presentation is a development of the research laboratories which are directed by Mr. C. F. Kettering, especially adapted for the CASMT audience. The select few who have had the privilege of seeing parts of this evolving program of demonstrations bear witness to the quality and possibilities of variations assured.

The next general meeting follows an afternoon of specialized section meetings. It is the annual banquet, scheduled for 7:00 P.M. Friday in the Grand Ball Room. It is fitting that this, the first CASMT banquet since 1941, have one of the splendid lecture-demonstrations of Dr. J. O. Perrine, of the American Telephone and Telegraph Company. Entitled "Radar and Microwaves," Dr. Perrine's theme will include the basic principles techniques and apparatus of electric wave phenomena for the purposes of electrical communication. Dr. Perrine comes to Detroit from New York specifically for this program.

The Saturday morning general meeting keeps up the standard by featuring a prominent engineering consultant, G. Edward Pendray, who will lend interpretation to concepts of power.

PEDAGOGY

Purer educational considerations of the various developments of the convention come into their own at the Saturday morning group meetings which are arranged with deference to standard levels of existing school organization. The Elementary Science and Elementary School Group Meeting is scheduled to hear Illa Podendorf, a CASMT member, from the University of Chicago Laboratory School. The Junior High School Group Meeting has scheduled Paul Jones, of Garden Educational Service for the Ford Motor Company, and Professor H. Vernon Price, Head of the Mathematics Department at University High School, State University of Iowa. Dr. Orren Mohler, of the University of Michigan, McMath-Hulbert Observatory at Lake Angelus, Michigan, is expected to give an illustrated lecture covering the products of the only motion picture solar observatory in existence, before the Senior High School Group Meeting. Professor Melvin J. Segal, of Michigan State College, is expected to appear before the Junior College Group Meeting to point out what the economist believes the scientist and mathematician can contribute to junior college general education. Professor Segal is said to think that this is a critical period. Professor George W. Starcher, of Ohio State University, may balance the program by presenting the point of view of the scientist or mathematician in this same connection. The Conservation Group Meeting is expected to continue its splendid reputation when Dr. Samuel T. Dana, Dean of the School of Forestry and Conservation at the University of Michigan, presents a discussion of "Forestry from the Human Welfare Standpoint," and Roberts Mann, Director of Conservation, Forest Preserve District, Cook County, Illinois, talks on "People in the Out-of-Doors."

PRACTICE IN INDUSTRY

Finally, a most unusual highlight of this CASMT convention is the trip.

For some it may be an adventure to see practical applications of the impacts of natural forces controlled, as calculated, to meet some everyday needs and wants of man. The Ford Motor Company will furnish free to members of the convention a lunch, transportation, and the rest of a most complete trip to the Rouge Plant, Greenfield Village and Edison Institute Museum. Guides and details, including placards have been prepared to render the trip and tour of the factory most successful from the point of view of the conventioner guest. At the Greenfield Village, exhibits abound, from early American experiments to Edison's contributions, and to the demonstrations of Mr. William Gassett. In the Edison Institute Museum Theatre, Mr. R. H. McCarroll, and Mr. W. S. James, will address the visitors on the topic "What Ford Engineers Are Thinking About For The Future."

HOSPITALITY

Hospitality is unanimously offered. Members of the teaching profession in this area have responded as in unison to recognize the worth of this convention. Not only do the welcoming groups represent the Metropolitan Detroit Science Club, the Detroit Biology Club, the Detroit Mathematics Club, the Detroit Physics and Chemistry Club, but also the Detroit Metropolitan Superintendents' Association. This is considered to be significant. In meeting with the Central Association of Science and Mathematics Teachers local advisory committee and chairmen of the local arrangements committees where the consideration was how best the work of the local arrangements committees can truly represent metropolitan Detroit in serving the 1946 CASMT convention, this group of administrative consultants did much to complete the multilateral recognition of a unity of purpose among educational leaders, whether they be classroom teachers, supervisors, administrators, or convening members of associations of the teaching profession. The local arrangements committee is deeply grateful for the contributions of all, and especially for the esprit de corps.

ALLEN F. MEYER,
CASMT General Chairman
Local Arrangements Committee

Why not secure your ROOM RESERVATION NOW by writing directly to Mr. C. B. Loftis, Front Office Manager, Book-Cadillac Hotel, Detroit 31, Michigan?

GOOD LOCAL SCIENCE JOURNALS

The Science Teachers Bulletin, official publication of the New York State Science Teachers Association, is edited by Victor E. Schmidt, State Teachers College, Cortland. It provides the science teachers of the state with science articles, news, questions, announcements of new books and apparatus, all for 40 cents a year, three years for $1.00.

Metropolitan Detroit Science Review is the official publication of the Metropolitan Detroit Science Club, edited by Louis Panush of Central High School and published quarterly, subscription price $1.00 per year. Teachers from Elementary Science on through the College are on the staff and put out an excellent science journal.

The Teaching Scientist is published four times a year by The Federation of Science Teachers Associations of New York. Its editor is Thomas G. Lawrence, Walton High School, Reservoir Avenue & 196th Street, Bronx 63, New York City. 32 pages. Science articles, teaching materials, laboratory and demonstration hints, book reviews. $1.00 a year.

PROFESSOR ALBERT PRUDEN CARMAN

Professor A. P. Carman was pre-eminently an educator, and a study of his career shows clearly that his chief interest and objective lay in this direction.

Born in 1861 in New Jersey, the son of a minister, he attended Princeton University and graduated from that institution in 1883 with the A.B. degree. The fact that he had already distinguished himself as a scholar is indicated by his appointment at that time as a teacher and fellow at Princeton. He also obtained the degree of Master of Arts there in 1884 and a Doctor of Science (Sc.D.) in 1886. While doing his graduate studies at Princeton, Professor Carman served as an instructor in physics and mathematics.

Still ambitious to learn and to prepare himself for the outstanding career which was to follow, Professor Carman attended the University of Berlin in 1888–1890 where he had the privilege of being a student of Helmholz.

Returning to America in 1890, he accepted the position of Professor of Physics and Electrical Engineering at Purdue University, serving in this capacity until 1893 when he joined the faculty of Stanford University as Professor of Theoretical Physics. He maintained the connection with Stanford until 1896, though the last year of this period was spent in further study at the University of Vienna.

It was in September of 1896 that Professor Carman came to the University of Illinois as head of the physics department and in charge of electrical engineering. At this time the profession of electrical engineering was rapidly developing and these duties were taken over by a full-time man in 1897, Professor Carman concentrating all his energies on physics. He remained as head of the department of physics until 1929, when he retired from active duty after serving the University of Illinois for thirty-three years.

Professor Carman was very proud of the department of physics, which grew up under his direction during his years of service to be one of the outstanding departments in the nation. In all these years Professor Carman exhibited a primary interest in training his students in the knowledge and appreciation of the laws of nature and in the growth and professional development of his colleagues.

During these years at Illinois he wrote the section on electricity and magnetism of the classical textbook of physics edited

by Duff. He saw to the planning and equipping of the present physics laboratory which, completed in 1910, remained one of the best laboratories of physics for many years. He organized the first professional curriculum in engineering physics in the United States anticipating by many years the importance of thorough training in physics now so clearly recognized by the foremost engineering schools.

While always maintaining a first interest in teaching, Professor Carman did find time for significant research. He directed important and fundamental research in the field of dielectrics, and cooperated with his staff in engineering research. He was aware that the good teacher must take an active interest in research, and encouraged his staff to maintain a like interest.

He was a great reader and spent many hours in the library of the department, keeping in touch with the rapid development in physics which occurred during his life. There were few items which escaped his attention, and the breadth and clarity of his understanding was often a surprise to those who sought his advice in technical fields.

All through his life he maintained a keen interest in his associates, and he counted as these all those who contributed to the development of knowledge, though he remained always loyal to his own field. This broad personal interest gave Professor Carman many friends, and he was respected and admired by all who knew him.

Coming to the University of Illinois in 1896, he knew the region when it was still a rural community. He took an active interest in the growth and development of the twin cities. He was married in 1900 to Maude Wheeler Straight, then on the University staff, and both Professor and Mrs. Carman took a keen interest in student activities.

Professor Carman experienced great loss in his later years due to failing vision. He met this difficulty, however, with cheerful fortitude and maintained his scholarly interests up to his death which occurred on the 10th of February, 1946.

His life will be remembered long as one of continued devotion to the cause of education. His loyalty to his work and to the University he served, is exemplary; his sincerity and personal integrity, outstanding. His scholarship was broad and sound, and he gave of his knowledge freely and unselfishly to the development of the University which he served. If we look in the University Register for 1944–45 we find the name of Albert

Pruden Carman following that of David Kinley. Both of these names will be gone from the Register of 1945–46. These men were contemporaries, and alike in their loyal service to the University of Illinois.

F. W. Loomis
E. H. Williams
R. F. Paton

LEWIS W. COLWELL

Lewis W. Colwell, 4140 Springfield Avenue, Chicago, formerly a teacher of mathematics in the Sullivan High School, died October 28, 1945.

CARL C. MILLER

Carl C. Miller, a teacher of biology and chemistry of the Central Senior High School of South Bend, Indiana, died December 31, 1945.

THE QUIZ SECTION

Julius Sumner Miller
Chapman College, Los Angeles, California

1. Every second degree equation in x and y represents a conic section. (T or F)
2. Every cross-section of a quadric surface is a conic section. (T or F)
3. The product of 2 conjugate complex numbers is a real number. (T or F)
4. Every algebraic equation has a root of the form $a+bi$. (T or F)
5. A kilogram of pure water occupies EXACTLY one liter. (T or F)
6. For an observer on the earth the sun and the moon have nearly the same angular size. (T or F)
7. Glowing coals are a very rich source of infra-red rays. (T or F)
8. Of the names Lamarck, Darwin, Spencer, Huxley, Jenner, the one out of place is————?
9. What is the Zodiac?
10. Taking the average amount of blood in a man as 5.5 liters, the number of red corpuscles as 5,000,000 per cubic millimeter of blood, and the diameter of each as 0.008 millimeter, how far would they extend, in miles, if placed end to end? Guess first, then calculate! (Sidney Hyde, Los Angeles)

ANSWERS TO THE QUIZ SECTION

1. T; 2. T; 3. T; 4. T; 5. F; 6. T; 7. T; 8. Jenner; 9. A narrow belt in the heavens in which the orbits of the planets are confined. (The planes of the orbits do not coincide.) 10. Approx. 130,000 Miles.

SCIENCE IN THE LAW ENFORCEMENT FIELD

JOHN EDGAR HOOVER

Director, Federal Bureau of Investigation, United States Department of Justice

Down through the ages the majority of the crimes committed by those who would flout the rules of organized society have been solved and the perpetrator punished. The solution, in some instances, was due in a great part to fortuitous circumstances, such as eye witnesses, the concatenation of time, place and persons and situations denying the possibility of any other conclusion. A few crimes, lacking these obvious physical manifestations, have remained unsolved.

Recognizing that these must also have a solution, the inquiring mind of science began developing new methods and techniques adapted to the discovery, the examination and the preservation of evidence in such cases. During the past few years scientific developments have moved from a minor to a major role in the processes of crime detection.

A very potent factor in criminal identification is the science of fingerprints. Its application in this field has not only brought about the apprehension of many fugitives who might otherwise have escaped arrest, but it has also made available to the judiciary the number of arrests and previous convictions of the person being tried, thus aiding greatly in the determination of the punishment to be meted out. It enables the prosecutor to present his case in the light of the offender's previous record and provides other officials, such as probation officers and parole board members, with definite information upon which to base their dealings with criminals in their jurisdiction.

Because it is peculiarly adapted to and exceedingly valuable in this field the science of fingerprints has always been closely associated with criminal identification. However, since fingerprinting has been proven to be a certain and infallible means of identification its application to other than criminal work has gained complete recognition. Of the more than 100,000,000 fingerprint records on file in the FBI Identification Division only slightly more than 15,000,000 are criminal. The remaining 85,000,000 are filed separately under such categories as Personal Identification, Civil Service, the various branches of the Armed Forces and many others.

The vast store of knowledge available in the Identification

Division of the FBI is applicable to many situations. A man giving the name of Henry Jones was arrested by a police department in the state of New York. The police had confidentially received information that he was wanted in Georgia for murder. Jones' fingerprint classification was telegraphically communicated to the Washington Headquarters of the FBI asking for any information concerning a man with that fingerprint classification and description. Simultaneously, the police department in New York State dispatched a telegram to the police

An expert reviews points of identification between an inked and a latent fingerprint in the Single Fingerprint Section.

department in Georgia asking if a Henry Jones was wanted for murder in that state. The police department in Georgia advised that there was no record of a Henry Jones being wanted for murder, but from the FBI Identification Division came word that Henry Jones' name was actually Joseph Wright and he was wanted in Georgia for murder.

The fingerprints of an amnesia victim in the Fresno County General Hospital at Fresno, California, were forwarded to the FBI by the Fresno County Bureau of Identification and Records. This woman could remember nothing concerning herself, not even her name. A search of her fingerprints through the files of the FBI Identification Division revealed an identical set

of prints which had been received from Portland, Oregon, in connection with the application of a woman for a position with a company which was engaged in war work in that city. In making this application she, of course, gave her correct name and address. The woman had no criminal record in the FBI files.

In Los Angeles, California, an unknown person was killed in a traffic accident. His fingerprints were forwarded to the FBI Identification Division. A set of fingerprints taken under the Alien Registration Law divulged the name, birthplace and date,

Technicians in the Technical Section complete the classification of all fingers.

the British citizenship of the unknown person and, in addition, the name and address of the person to be notified in case of an emergency.

In August, 1944, a mother residing in the state of Washington asked the FBI to assist in locating her son. Her letter enclosed a set of fingerprints of the son taken in 1926 when he was three years of age. She also advised that the boy's father had placed him in a home for adoption when the child was four years old and she had not seen him since that time. The fingerprints sent by the mother were immediately identified with those of a young man who had enlisted in the United States Navy at Des Moines,

Iowa, in August, 1941. Thus this mother was able to contact her long lost son because his fingerprints remained an unchanging record of his identity.

On September 14, 1944, a number of individuals were killed in a train wreck at Terre Haute, Indiana. Among the victims were a number of servicemen who had recently returned from overseas. Difficulty was experienced in identifying some of the bodies, and fingerprints were forwarded to the Federal Bureau of Investigation along with the names of military personnel who were believed to be victims.

Experts in the FBI Identification Division carefully checked the incoming fingerprints with others on file at the FBI and found that eight of the fingerprints from the wreck matched fingerprints already in the FBI files under names identical with those sent in from Indiana. The other two prints, however, were not identical with those of military personnel whose names were given, but a search of the FBI files disclosed that the prints were identical with those of other soldiers whose names had not been furnished.

Additional fingerprints were sent to the FBI, and three other soldier victims of the train wreck also were positively identified. Information on the correct identity of the servicemen victims was furnished promptly to military authorities, so that appropriate action could be taken towards the notification of relatives.

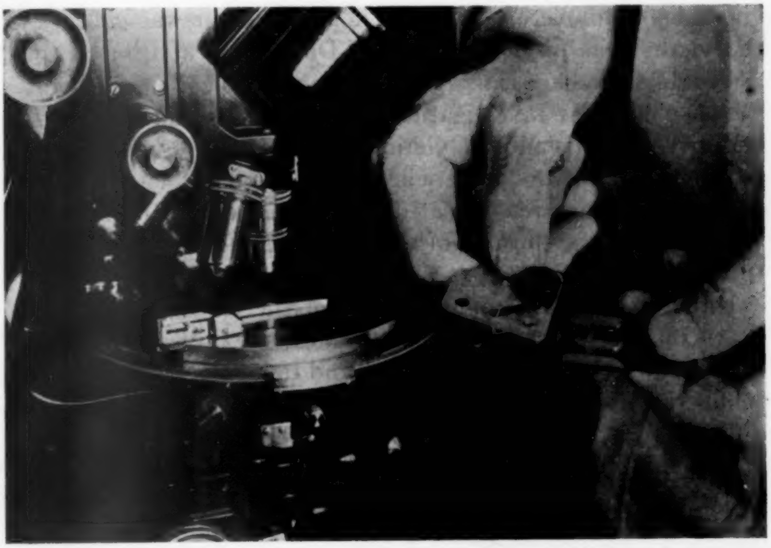
These are only a few examples of the countless ways that fingerprints serve to establish identity. They are a record not subject to the fallacies germane to other means dependent upon time, place and name.

Fingerprinting is only one of the sciences which inestimably assist in the problem of law enforcement and scientific crime detection. In its work in the criminal field the FBI has been called upon for assistance through the whole gamut of crime ranging from Abortion, Arson, Assault and Battery to Train Wrecks. In the solution of these crimes the FBI Laboratory by application of scientific principles has become a most valuable aid.

Since its establishment in 1932 the Laboratory has grown from a unit having a single man and a microscope to one staffed with scientists from various fields and containing machinery and equipment having a value of more than a million dollars. Today the Laboratory is equipped with every practical piece of scientific and precision apparatus which by careful experimenta-

tion has been currently and continually useful in criminal investigation.

The facilities of the FBI Laboratory are available not only to the Special Agents of the Federal Bureau of Investigation but also to municipal, county and state police authorities and to agencies of the Federal Government. Upon their request examinations are made for such organizations in connection with criminal inquiries being conducted under their jurisdiction. The



Cross sectioning a group of hair fibers by the use of a hardy microtome preparatory to microscopic study for identification technical laboratory, Federal Bureau of Investigation, United States Department of Justice.

Laboratory conducts a great deal of research and develops methods looking toward the application of established scientific methods to crime detection and the law enforcement problem generally.

During the course of its existence it has been found necessary to widen the scope of the FBI Laboratory to cover practically every scientific field. Over eighty-eight branches of science and the subdivisions thereof have been applied in the Laboratory in the examination and discovery of evidence in criminal cases. These sciences cover the field from aeronautics to zoology, including analytical chemistry, biochemistry, electrochemistry, electrical engineering, organic chemistry, microscopy, trichol-

ogy, spectrography, histology, toxicology and many others. These sciences have been applied in criminal cases extending from Abortion to Unlawful Flight to Avoid Prosecution.

An examination of some of the cases will best portray the value of science in law enforcement.

During the evening of March 24, 1945, Walter Curtis carried the body of Catherine Gross into her home at Prince Frederick, Maryland, and placed it on a bed. He told the girl's parents that she was drunk and would be all right in the morning. When the girl failed to move after several hours a doctor was called and the victim was pronounced dead. Death was attributed to a cerebral hemorrhage caused by a blow on the head.

Police began an investigation and were able to find a man who had driven Curtis and the victim to her home. He pointed out a spot in a nearby woods where he said he had first seen the couple. A search of this area revealed three large clubs. These clubs, together with the clothing of the suspect and victim, were taken to the FBI Laboratory.

Human blood was found on two of the clubs. Heavy black fibers on another of the clubs, which the investigators had thought were human hairs, were found to be black rayon similar to fibers in an artificial fur collar on the victim's coat. Five different colors of green wool fibers were found clinging to two of the clubs, all of which were similar to green wool fibers in the victim's coat. In addition yellow, red and black cotton fibers were found on one of the clubs which were similar to those in a plaid shirt worn by the suspect.

Laboratory examiners testified to the above facts at the trial on May 9, 1945. Curtis was found guilty and sentenced to ten years for second degree murder. The aid of microscopy in this case was indispensable for without it vital evidence might have been lost.

In another case microscopy and spectrography played important parts. In Charleston, West Virginia, five men suspected of stealing a safe and hauling it away in an automobile were apprehended. A thorough search of the trunk of the car revealed several small chips of paint on the floor.

These were forwarded to the FBI Laboratory together with known paint removed from the recovered safe. A Laboratory technician found that both samples consisted of correspondingly colored and textured layers of black and gray paint, and that both the gray layers contained minute white flecks. In addition

both showed small fragments of light green paint which apparently had been spattered on the surface, and small amounts of bronze or gilt paint were present.

In view of the testimony to be offered by the Laboratory technician, all five of the suspects pleaded guilty and were sentenced to twelve months in jail.

At about 6:30 P.M. on April 27, 1944, the badly mutilated body of a 17-year-old Indian girl was found on the South Tongass highway near Ketchikan, Alaska. An examination reflected that the girl had been struck by an automobile traveling at a high rate of speed. No witnesses to the accident could be found.

A Special Agent of the Federal Bureau of Investigation, accompanied by a United States Marshal, began an investigation of the case. They examined the automobiles of all persons who were known to have driven along this highway on that night. The following day they located a truck on which the bumper and radiator grille appeared to have been damaged. A closer examination disclosed that a fibrous material resembling hair was present on the clamp lock of the left front headlight, the right bumper bolt, and under the right running board of the truck. In addition, a white material was found on the undercarriage of the vehicle. This evidence was forwarded to the FBI Laboratory, together with known head hair specimens of the victim.

A trichological examination of the fibrous substance removed from the truck disclosed that it was human hair bearing characteristics of the Mongoloid race and similar in its observable characteristics to the known head hair specimens of the victim. In addition a histological examination of the white tissue removed from the undercarriage identified it as human brain tissue. Found in this brain tissue were some erythrocytes or red corpuscles which were in the shape of sickles indicating the victim was suffering from dretanocytosis or sickle-celled anemia. Since this disease is rarely found in the white or Caucasian race it was of added assistance in the examination of this evidence.

The trial of the driver of the truck, Edward Ross Kimball, was set for November 7, 1944. The FBI technician who had examined the hair and brain tissue was called to Ketchikan, Alaska, to testify. A great deal of interest was centered in the trial since it was the first hit-and-run case and the second negligent homicide case ever to be tried in Alaska.

At the beginning of the trial the defendant pleaded not guilty. Under cross-examination on the stand, however, Kimball ad-

mitted having run over something in the road that could have been a body, but insisted that if it was a body it was lying in the road and was not in a standing position.

The Laboratory examiner testified that the three strands of

Expert making an examination of shotgun shells under the comparison microscope at the technical laboratory of the Federal Bureau of Identification, United States Department of Justice.

hair which had been removed from the clamp lock of Kimball's truck were human hairs bearing characteristics of the Mongoloid race, which would include the Indian, and could have come from the victim's head. Using this testimony, the prosecution pointed out that the victim must necessarily have been in a standing or semi-standing position at the time she was struck.

On November 10, 1944, Kimball was found guilty of negligent homicide and sentenced to eighteen months in prison.

All day September 3, 1944, Howard Marsh quarrelled with his wife, Rosa, at their home near Whiteville, North Carolina. That evening he beat his wife and made her go to bed. As she lay on the bed with their 19-months-old infant, Thomas, in her arms, Howard Marsh lay down on the other side of the bed fully clothed with a .25 caliber Colt automatic pistol in his pocket. Suddenly he turned, cried out, "Won't I kill you though!" A shot rang out. The bullet entered the back of the baby, Thomas, and passed through his body, causing his death.

Investigators who hurried to the scene were given details by Rosa Marsh, but they realized that she would not be competent to testify in court against her husband and there were no other eye witnesses to the slaying. However, a bullet was found lodged in the mattress of the bed where the murder occurred, and bullet holes, powder marks and stains which appeared to be blood were found on three bed sheets. When Howard Marsh was arrested, a .25 caliber automatic pistol was found, and this, together with the bullet found in the mattress and the sheets from the bed, was transmitted to the FBI Laboratory for examination.

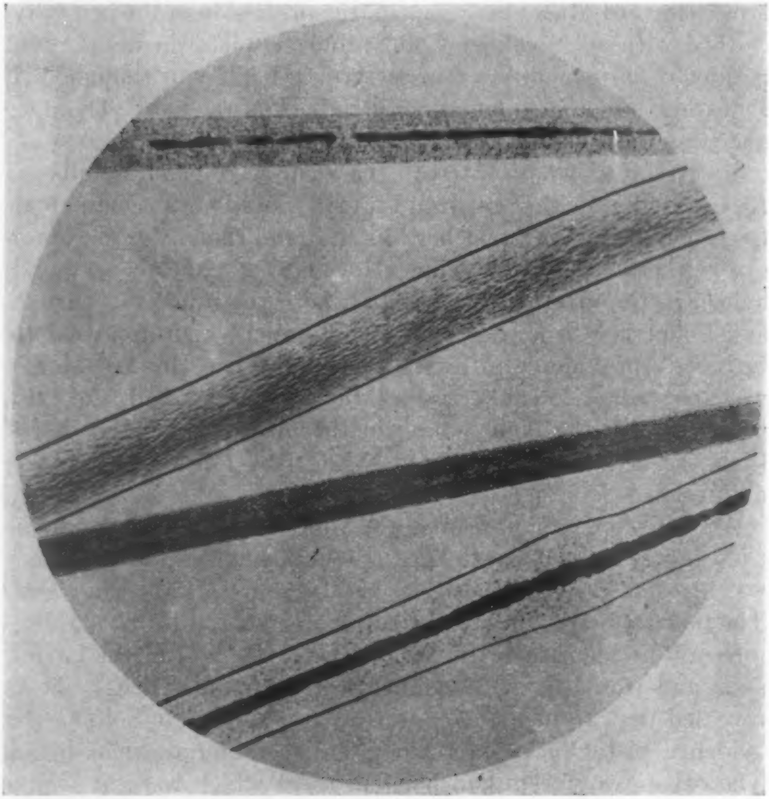
A microscopic comparison of the bullet and test bullets fired in the .25 caliber automatic pistol found when Howard Marsh was arrested revealed that they had been fired in the same gun. The powder marks on one bed sheet were found to have a definite outline identical with the outline of the end of the barrel, slide and frame of a .25 caliber Colt automatic pistol. Tests revealed that an identical pattern was obtained by holding the evidence pistol in contact with similar material when firing. The other two sheets had holes in them which were of such a size that they could have been made by a .25 caliber bullet. In addition, the stains on all three sheets were found to be human blood.

Impressed by the weight of the scientific evidence against him, Howard Marsh pleaded guilty and was sentenced to not less than 15 nor more than 20 years in the State Penitentiary for the slaying of his infant son.

A human body, weathered to bare bones and found by hunters in the Arbuckle Mountains, lay unidentified in an Ardmore, Oklahoma, funeral home until a report from the FBI Laboratory reached local officers.

A few fragmentary pieces of molded paper matted together

and several hair specimens found near the bones were the only clues furnished the FBI Laboratory. The hair specimens were identified as belonging to a member of the white race. The submitted paper specimens were found to consist of two one-dollar bills, fragments of an envelope, and several miscellaneous pieces



Longitudinal whole mounts of human hair from different individuals showing characteristic structures through increased magnification.

of paper. Through the use of infrared and ultraviolet photography and the application of various chemical tests, it was possible to make the writing on the fragments of the envelope visible. It was also possible to read directly several complete names and addresses on the other miscellaneous paper specimens, after they had been carefully separated. Among the addresses brought up on the miscellaneous pieces of paper were three individuals with the surname of "Landrith."

It was learned later that the FBI report was instrumental in establishing beyond a reasonable doubt that the tragic victim of the mountains was Lee Landrith, 44, and that the Landrith addresses were for brothers of the deceased. The sheriff at Ardmore notified relatives of the deceased after receiving the report from the FBI.

These are representative of the many types of cases submitted to the Laboratory. Since its inception over a million such examinations have been conducted. During the fiscal year of 1945 alone 136,098 examinations were conducted involving 194,445 specimens of evidence.

The exigencies of war called many of the men of law enforcement into the Armed Forces. These men are now going back to their respective departments. Although statistics show that crime is on the increase this returning manpower coupled with science will meet the challenge of crime with firm determination.

RADO TO BECOME HEAD OF MATHEMATICS AT OSU

Appointment of Dr. Tibor Rado as chairman of Ohio State University's department of mathematics was announced today by President Howard L. Bevis, following approval by the board of trustees.

Dr. Rado, nominated for the position by Dean Harlan Hatcher of the Arts College, takes the place of Dr. John L. Synge, who has resigned, effective September 30, to head the applied mathematics division of Carnegie Institute of Technology, Pittsburgh. Synge has been chairman since 1943, when he came here from the University of Toronto.

The newly-appointed chairman has been on the Ohio State staff since 1930, with the rank of full professor. Nationally known for his writings on mathematics, including twelve books and more than sixty research papers, he was accorded one of the highest honors in his field last November when he was selected to give the "Colloquium Lectures," a series of four addresses, before the annual meeting of the American Mathematical Society in Chicago.

Born in Budapest, Hungary, Rado received the doctor of philosophy degree from the University of Szeged in his native country in 1921. He remained on the staff of that university until 1929, when he was appointed to an International Research Fellowship of the Rockefeller Foundation. During 1929–30 he was a visiting lecturer, first at Harvard University and later at Rice Institute. He then came to Ohio State.

In 1942 he was a visiting professor at the University of Chicago, and in 1944–45 he was on leave from Ohio State for a fellowship at the Institute for Advanced Study, Princeton, N. J. In the summer of 1945 he was a scientific consultant for the Army Air Forces in England, France and Germany.

Dr. Rado is a member of the American Mathematical Society, the American Mathematical Association; Phi Mu Epsilon, mathematical fraternity; Sigma Xi, scientific honor society; Torch Club, and other local groups. He has served as one of the editors of the *American Journal of Mathematics.*

CLOSING THE GAPS IN THE NUMBER SYSTEM

P. H. Nygaard

North Central High School, Spokane, Wash.

I. From Integers to Imaginaries

Kronecker's statement, that "God made integers, all else is the work of man," does not miss the truth very far. Integers came into use so early in the history of civilization that it is reasonable to doubt whether they are an invention of our primitive ancestors or are a part of man's intuitive mentality. Infants only a few days old are probably aware of the difference between one and two. Children in the lower grades are able to count, and can carry out the operations of addition, subtraction, multiplication, and division. The results which they obtain by adding integers and multiplying integers are never anything but integers. In other words, integers form a closed field with respect to the operations of addition and multiplication.

Such is not the case with respect to division. If you ask a second or third grade child how many times 3 goes into 6, you will get an immediate answer of 2, but if you ask how many times 3 goes into 7, you will get either a blank stare or the answer, "3 won't go into 7." Such division problems are truly impossible to the child, because their solution requires the invention of a new type of number called fractions. The Egyptians and Babylonians had invented fractions probably as early as 4000 or 5000 B.C. With fractions admitted into the number system, the operations of addition, multiplication, and division are always possible. The child in the upper grades learns to accept fractions on a par with the integers, sometimes seeing nothing grewsome even in $\frac{3}{4}$ of a boy. In order to keep the argument straight it should be made clear that division by zero is impossible, not only to the grade school child, but to all mathematicians. Nothing to be mentioned in this paper will remove this restriction,—in fact, it is probably the only restriction on number operations which will not be removed.

The operation of subtraction is the next one to give trouble. If you ask the grade school child to take 5 from 8, you will be told at once that the answer is 3, but if you ask him to take 5 from 2, you will most likely be informed that, "it can't be done." You see the child has not yet heard about negative numbers, which came into common use hundreds of years ago. In

9th grade algebra these negative numbers become so familiar to the student that he may not hesitate even to accept a solution calling for a negative number of men needed to dig a ditch. With the introduction of negative numbers and fractions, the four operations of addition, subtraction, multiplication, and division always give results that come within the field of accepted numbers.

About this time, when everything is seemingly under control, the student runs into other operations beyond the four already mentioned. He hears about powers and roots of numbers. The square root of 36 is $+6$ or -6, but what of the square root of 96? There is no integer, fraction, or negative number which can be used to indicate the result. Perhaps 96 doesn't have a square root? Mathematicians have, however, invented irrational numbers to take care of such emergencies. The answer is simply $\sqrt{96}$ or $4\sqrt{6}$. Such irrationals can be approximated to any degree of accuracy by means of fractions or decimals. Besides learning to handle radicals glibly in his algebra, the student gets acquainted with other irrationals, such as π. The acceptance of irrational numbers makes it possible to find any root of any positive number. All the numbers so far admitted to the number system are called real numbers.

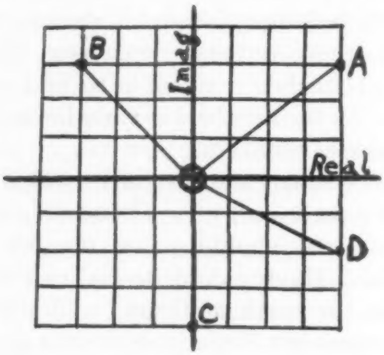
The operation of square root produces still another dilemma. What about the square root of -4? Should such an operation be called impossible or should a new number be invented to indicate the result? Having done pretty well in their previous creative exploits, the mathematicians couldn't resist the urge to devise another number. The square root of any negative number is called an imaginary number. The designation i is given to $\sqrt{-1}$, and all imaginary numbers can be expressed as i times a real number. The complex number was a correlative development. It is simply a binomial, one term of which is real and the other imaginary,—such as, $-3+\sqrt{-7}$, usually written $-3+i\sqrt{7}$. It was discovered that cube roots, fourth roots, and all higher roots of negative numbers could be expressed as complex numbers. Thus imaginaries took care of all root problems.

The operation of raising a number to a given power leads to no new numbers. Negative exponents can easily be avoided by changing x^{-n} to $1/x^n$. Fractional exponents serve as only alternate methods of indicating roots,—for instance, $x^{1/n}=\sqrt[n]{x}$. Raising a negative number to an irrational power results in a complex number. Even finding a complex power of a complex number leads only to another complex number.

It may therefore be stated that the six fundamental operations of adding, subtracting, multiplying, dividing, raising to a power, and extracting a root can be performed within the field of integers, fractions, negative numbers, irrationals, and complex numbers, without ever getting a result outside this field. The purpose of the remainder of this paper will be to show some of the intricacies involved in these operations.

II. Some Number Complexities

After an algebra class has learned the rudiments of imaginary numbers, some inquisitive student is sure to want to know: "If $\sqrt{-1}=i$, then what is $\sqrt{i}$?." Another student may be worried about whether $(-1)^{\sqrt{2}}$ equals -1 or $+1$, since it is impossible to determine whether $\sqrt{2}$ is an odd or an even number. If the class has been informed by the teacher, or through the textbook, that no algebraic computation problem is impossible



to one who understands complex numbers, a little problem like 2^i may be proposed for the teacher's mental exercise. In this section these and similar problems will be solved by methods based largely on De Moivre's Theorem and Euler's Formula.

A complex number is a binomial of the form $a+bi$, in which a and b are any real numbers and $i=\sqrt{-1}$. If a is zero, the number is a pure imaginary; if b is zero, the number is real. Complex numbers can be graphically represented as points, using a rectangular coordinate system in which the customary X and Y axes are respectively used to lay off the real and the imaginary terms of $a+bi$. Thus in the accompanying figure, $A=4+3i$, $B=-3+3i$, $C=0-4i=-4i$, and $D=4-2i$.

Polar coordinates are frequently used to represent complex

numbers. In this system the line segment from the origin to the point is called the radius vector (or modulus), and the angle of rotation from the OX axis to the radius vector in a counter-clockwise direction is called the vectorial angle (or amplitude). In this paper the radius vector will be r and the vectorial angle x. By elementary trigonometry it can be shown that $a+bi=r\cdot\cos x+ri\cdot\sin x=r(\cos x+i\cdot\sin x)$, in which $r=\sqrt{a^2+b^2}$ and $x=\arctan b/a$. So in figure 1 $A=5(\cos 36°52'+i\cdot\sin 36°52')$; $B=3\sqrt{2}(\cos 135°+i\cdot\sin 135°)$; $C=4(\cos 270°+i\cdot\sin 270°)$; $D=2\sqrt{5}(\cos 333°26'+i\cdot\sin 333°26')$. The vectorial angle is usually stated in radian units; conversion from degrees to radians, or vice versa, may be effected by the relationship, π radians$=180°$. Using radians, $A=5(\cos .6435+i\cdot\sin .6435)$; $B=3\sqrt{2}(\cos 3\pi/4+i\cdot\sin 3\pi/4)$; $C=4(\cos 3\pi/2+i\cdot\sin 3\pi/2)$; $D=2\sqrt{5}(\cos 5.82+i\cdot\sin 5.82)$. For any vectorial angle x, the same position will be attained if the vectorial angle is $360°+x$, or $720°+x$, etc. Hence, the identity, $a+bi=r(\cos x+i\cdot\sin x)$, can be generalized to the form,

$$a+bi=r[\cos(2\pi n+x)+i\cdot\sin(2\pi n+x)], \qquad [1]$$

in which 2π is the radian equivalent of $360°$ and n is any positive integer or zero.

De Moivre's well known theorem provides an easy method of finding powers of complex numbers. It states that

$$(a+bi)^k=r^k[\cos k(2\pi n+x)+i\cdot\sin k(2\pi n+x)], \qquad [2]$$

in which k is any real number. Thus, using $n=0$, $(\sqrt{3}+i)^4=2^4[\cos 4(\pi/6)+i\cdot\sin 4(\pi/6)]=16(-\frac{1}{2}+\frac{1}{2}i\sqrt{3})=-8+8i\sqrt{3}$. This result can be checked by multiplication. If n is taken to be 1, 2, 3, etc., obviously no new results will be obtained. Roots can also be found by formula [2]. Suppose it is desired to find the cube root of $-2+2i$. Then, using $n=0$, $(-2+2i)^{1/3}=(\sqrt{8})^{1/3}[\cos\frac{1}{3}(3\pi/4)+i\cdot\sin\frac{1}{3}(3\pi/4)]=\sqrt{2}(\frac{1}{2}\sqrt{2}+\frac{1}{2}i\sqrt{2})=1+i$. By setting $n=1$ and $n=2$, the approximate values $-1.366+.366i$ and $.366-1.366i$ are found, but other integral values of n give only repetitions of roots already found. All three of these cube roots of $-2+2i$ can be readily verified by multiplication. To find the square root of i, using $n=0$ in formula [2] gives $(0+1\cdot i)^{1/2}=1^{1/2}[\cos\frac{1}{2}(\pi/2)+i\cdot\sin\frac{1}{2}(\pi/2)]=\frac{1}{2}\sqrt{2}+\frac{1}{2}i\sqrt{2}$. Using $n=1$ gives $(0+1\cdot i)^{1/2}=1^{1/2}[\cos\frac{1}{2}(5\pi/2)+i\cdot\sin\frac{1}{2}(5\pi/2)]=-\frac{1}{2}\sqrt{2}-\frac{1}{2}i\sqrt{2}$. Other values of n produce no additional roots.

A second discovery of great importance in dealing with num-

bers is known as Euler's Formula. It states that $e^{ix} = \cos x + i \cdot \sin x$, or more generally that

$$e^{ix} = \cos (2\pi n + x) + i \cdot \sin (2\pi n + x), \qquad [3]$$

in which x is the vectorial angle in radians, $i = \sqrt{-1}$, $n = 0, 1, 2, 3$, etc., and e is the natural logarithm base whose value is approximately 2.71828. This formula provides a third method of expressing complex numbers. Formula [1] states that $a+bi = r[\cos (2\pi n + x) + i \cdot \sin (2\pi n + x)]$. Hence it follows that

$$a + bi = r \cdot e^{i(2\pi n + x)}, \qquad [4]$$

r being the radius vector, x the vectorial angle, and n is 0, 1, 2, 3, etc.

If x is set equal to π and $n = 0$, formula [3] becomes

$$e^{i\pi} = \cos \pi + i \cdot \sin \pi, \quad \text{or} \quad e^{i\pi} = -1, \qquad [5]$$

one of the most striking relationships in all mathematics, including as it does the important irrational constants e and π, the imaginary unit i, and the negative unit -1. Formula [5] is equivalent to the statement that $\log(-1) = i\pi$, the logarithm base being e. This shows that negative numbers have logarithms, but they are imaginary. Taking the square root of each side of [5] gives $e^{i\pi/2} = i$, and raising each side of this last equation to the power i gives $e^{-\pi/2} = i^i$,—in other words, i^i is a real number equal to about .208.

To find 2^i, set $2 = e^{\log 2}$, in which the natural logarithm is to be used. The natural logarithm of a number is obtainable from its common logarithm by multiplying the latter by 2.3026. Now $2^i = [e^{\log 2}]^i$. Then by formula [3], $2^i = \cos(\log 2) + i \cdot \sin(\log 2) = .769 + .639i$. This is not the only value of 2^i; using $n = 1, 2, 3$, etc., produces a multiplicity of values. The value of $(-1)^{\sqrt{2}}$ can now be found. By formulas [5] and [3], $-1 = e^{i\pi}$, so $-1 = \cos(2\pi n + \pi) + i \cdot \sin(2\pi n + \pi)$. Hence by formula [2], $(-1)^{\sqrt{2}} = 1^{\sqrt{2}}[\cos \sqrt{2}(2\pi n + \pi) + i \cdot \sin \sqrt{2}(2\pi n + \pi)]$. For $n = 0$, $(-1)^{\sqrt{2}} = 1 \cdot [\cos \pi\sqrt{2} + i \cdot \sin \pi\sqrt{2}] = -.267 - .964i$. Again other values are found by using $n = 1, 2, 3$, etc.; none of these, however, is $+1$ or -1.

III. A Proposed General Formula

Since the addition, subtraction, multiplication, and division of complex numbers are obviously easy to perform, the only troublesome cases occur with respect to powers and roots.

Since roots can always be expressed in terms of powers by means of fractional exponents, a complete analysis of raising a number to a power will allay all difficulties. A formula so inclusive that it applies to all such cases will now be proposed.

The general problem is to find $(a+bi)^{c+di}$, a, b, c, and d being any real numbers, and $i=\sqrt{-1}$. By methods previously explained, it is not difficult to demonstrate that

$$\begin{aligned}(a+bi)^{c+di}&\\ &=r^c\cdot e^{-d(2\pi n+x)}\cdot[\cos d(2\pi m+\log r)+i\cdot\sin d(2\pi m+\log r)]\\ &\quad\cdot[\cos c(2\pi n+x)+i\cdot\sin c(2\pi n+x)],\end{aligned}\qquad[6]$$

in which $r=\sqrt{a^2+b^2}$, $x=$ radian value of arctan b/a, $e=$ natural logarithm base, m and n can be taken independently to equal 0, 1, 2, 3, etc., log r is to the base e, and $2\pi=6.2832$ which is the radian equivalent of 360°. What may be called the principal value is obtained by setting $m=0$ and $n=0$ in this formula. By using larger values of m and n, some problems will be seen to have only a finite number of possible solutions, whereas others will have an unlimited number. The formula will run the complete gamut of power problems, ranging from 2^3 and $\sqrt[3]{8}$ to $(-3)^{2i}$ and $(-1+i\sqrt{3})^{\sqrt{2}+i}$. Each of these four will be solved to illustrate the generality of formula [6].

For 2^3, $a=2$, $b=0$, $c=3$, $d=0$, $r=2$, and $x=0$. Using $m=n=0$, $2^3=2^3\cdot e^0\cdot\cos 0\cdot\cos 0=8$. Other values of m and n give no new values.

For $\sqrt[3]{8}$, $a=8$, $b=0$, $c=\frac{1}{3}$, $d=0$, $r=8$, and $x=0$. Using $m=n=0$, $\sqrt[3]{8}=8^{1/3}\cdot e^0\cdot\cos 0\cdot\cos 0=2\cdot 1\cdot 1\cdot 1\cdot=2$. Since $d=0$, the value of m is immaterial, but other values of n will give changed results. For $n=1$, $\sqrt[3]{8}=8^{1/3}\cdot e^0\cdot\cos 0\cdot[\cos(2\pi/3)+i\cdot\sin(2\pi/3)]=2\cdot1\cdot1\cdot(-\frac{1}{2}+\frac{1}{2}i\sqrt{3})=-1+i\sqrt{3}$. For $n=2$, $\sqrt[3]{8}=8^{1/3}\cdot e^0\cdot\cos 0\cdot[\cos(4\pi/3)+i\cdot\sin(4\pi/3)]=2\cdot1\cdot1\cdot(-\frac{1}{2}-\frac{1}{2}i\sqrt{3})=-1-i\sqrt{3}$. Other values of n are repetitive. Hence the formula gives the three familiar cube roots of 8.

In finding $(-3)^{2i}$, $a=-3$, $b=0$, $c=0$, $d=2$, $r=3$, and $x=\pi$. Using $m=n=0$, $(-3)^{2i}=3^0\cdot e^{-2\pi}\cdot[\cos(2\log 3)+i\cdot\sin(2\log 3)]$. $\cos 0=1\cdot(.00187)\cdot(-.586+.810i)\cdot 1=-.0011+.0015i$. Other values of m give an unlimited number of different solutions.

To find $(-1+i\sqrt{3})^{\sqrt{2}+i}$, set $a=-1$, $b=\sqrt{3}$, $c=\sqrt{2}$, $d=1$, $r=2$, and $x=2\pi/3$. Using $m=n=0$, $(-1+i\sqrt{3})^{\sqrt{2}+i}=2^{\sqrt{2}}\cdot e^{-2\pi/3}\cdot[\cos(\log 2)+i\cdot\sin(\log 2)]\cdot[\cos(2\pi\sqrt{2}/3)+i\cdot\sin(2\pi\sqrt{2}/3)]=(2.66)\cdot(.123)\cdot(.769+.639i)\cdot(-.984+.179i)=-.284-.160i$. In

this problem other values for m and n give an unlimited number of solutions.

The reader will find it interesting to test formula [6] by means of a variety of examples of his own choosing. It can be used, for instance, to show that all four of the fourth roots of -1 are complex numbers, thus making it evident that fourth, or higher, roots of negative numbers do not necessitate any extension of the number field. Any of the results given in the second section of this paper may be obtained also by formula [6],—such as, $e^{i\pi}=-1$ and $i^i=e^{-\pi/2}$.

A NEW MICROSCOPE EXPLORES THE INVISIBLE

New equipment which transforms an ordinary light microscope into an instrument that extends the range of human vision far beyond the limits of present microscopes was announced by American Optical Company's Scientific Instrument Division.

Officials of the division said the new equipment, when added to a standard microscope, permits the observation and study of many living cells, tissues, microorganisms and industrial materials so transparent that heretofore little or no detail could be seen in them.

This fundamental advance in the use of the microscope is called phase microscopy and the converted instrument a phase microscope. The new microscope equipment consists of newly developed light-controlled diffraction plates. Placed in an objective lens system, the plate makes detail visible within a specimen by increasing, reducing or reversing contrast in the image formed by the microscope.

One of the features of the new phase microscope is that it makes possible an accurate study of transparent living organisms. Formerly, to make them visible it was usually necessary to stain them with dyes, a procedure that kills most organisms. As a result, most of the information gained in the past with the microscope was limited to the study of dead rather than living material.

The new phase microscope will be useful in the study of plant and animal life, parasites, emulsions, replicas of metal and other surfaces, glass and plastic transparent surfaces, minerals, crystals, synthetic fibers and other materials.

In the field of biology many significant experiments can now be made and the effects fully studied with the new instrument. For example, tiny chambers can be constructed on microscope slides to imprison living organisms. These chambers can be utilized to supply nutrients and oxygen, and to remove toxic excretions. Thus, the effect on the organisms of many agents, including drugs and vitamins, can be investigated.

In the field of industry innumerable applications are possible. For instance, crystals otherwise barely visible can be seen. In reverse order, regions within certain substances can be made invisible, facilitating the discovery of impurities.

SOME WAR-TIME DEVELOPMENTS IN CHEMISTRY

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III. Organic Materials

The complicated interdependence of modern life is strikingly illustrated by the alcohol situation which developed during the war years. In ordinary times the chief raw materials used in producing ethyl alcohol are molasses and grain. Because of the world wide food and meat shortages it has become necessary to use smaller and smaller amounts of edible grains in the production of alcohol. The supply of molasses could not be increased because of the critical shortage of sugar. The demand for alcohol was greatly increased by the fact that large quantities of this essential material were required for numerous war projects. Chief of these was the use of alcohol for the manufacture of butadiene which is needed in the production of synthetic rubber. In 1944 there were set aside 330 million gallons of alcohol for making butadiene. Increased demands for various drugs also intensified the need for alcohol. In order to meet this critical need the manufacture of beverage alcohol was suspended and all facilities of the breweries and distilleries were used to produce alcohol for manufacturing purposes. Many additional raw materials were used, such as excess potatoes, both Irish from Maine, and sweet from Florida, bananas from Jamaica, and the sulfite liquors from paper pulp mills. About 65 million gallons of alcohol were obtained by the hydration of ethylene, a by-product, produced in the cracking of petroleum or in cracking propane from natural gas. Concerted efforts have been made to perfect a method of obtaining alcohol from wood waste. The most promising method, known as the Scholler process, consists in the hydrolysis of wood chips by sulfuric acid at elevated temperature and under pressures up to 150 pounds per square inch. It is reported that soft woods like Douglas fir, spruce and southern yellow pine will yield a quantity of reducing sugars equivalent to 45–57% of the weight of the dry wood. Where this wood sugar is fermented 40–60 gallons of alcohol are obtained from a ton of spruce or pine. The cost is still high but it is estimated that the cost of the wood will represent more than half the expense of the entire operation. By-products, such as tannin, lignin, butyl

alcohol, acetone and isopropanol, may be made to carry part of the cost. It has been stated that the production of alcohol from wood cannot by itself compete successfully with alcohol from molasses unless the cost of molasses is more than 5 cents per gallon. It will be interesting to watch the development of these two competing sources of ethyl alcohol.

The critical phase of the alcohol situation was relieved during the first half of the year 1944, and during the month of August of that year the manufacture of alcoholic beverages was permitted. The important contribution made by the brewing industries is shown by the fact that during the period from January 1, 1942, to the beginning of the alcohol "holiday" (August 1, 1944) the alcoholic beverage industries contributed more than 480 million gallons of alcohol to meet the national emergency. This was nearly half of the total production from all sources during this period. By the end of the year 1944, the production of alcohol was adequate and this national shortage no longer existed.

Because of the scarcity of sugar there has been unusual interest in the announcement that sucrose has been synthesized by Drs. W. Z. Hassid, Michael Donderoff, and H. A. Barker of the University of California. Their method consists in producing a reaction between fructose and glucose phosphate by the aid of an enzyme. In this reaction a molecule of phosphoric acid is eliminated and the two simple sugars are combined to form sucrose. Only a few grams of sugar were made by this method, so there is no hope for relief of the sugar shortage in this process. But it is a scientific triumph of much interest because chemists for years have been unsuccessful in making this important synthesis. Menthol ($C_{10}H_{20}O$) is a secondary alcohol which is obtained from peppermint oil or other mint oils, or prepared by the hydrogenation of thymol ($C_{10}H_{14}O$). It is widely used as an analgesic to alleviate minor aches and pains, insect bites and such irritations. Formerly the United States imported a half million pounds annually, mostly from Japan. Much of the supply was cut off during the war and the consequent shortage stimulated efforts to produce a synthetic source. The United Drug Company has developed a new method which is expected to meet the demand for menthol at a lower price than that asked for the natural product.

Maleic and fumaric acids are isomeric compounds of the formula $C_4H_4O_4$. The demand for maleic acid has increased ma-

terially because of its use in the manufacture of artificial resins and in dyeing and finishing wool, cotton and silk. A new method of manufacture has been announced by Dr. W. L. Faith. It uses as starting material cheap hydrocarbons which are by-products of other industries. These are chlorinated, then oxidized in the vapor state and finally hydrochloric acid is eliminated. The advantage of this new process depends upon the manufacture of a useful substance from material which would otherwise be of little use.

Caffeine, a stimulating alkaloid of the formula $C_8H_{10}N_4O_2$, is usually extracted from waste tea, coffee or cocoa. The demand for caffeine has increased greatly because of its use in the manufacture of the popular cola beverages. It is also used widely in pharmaceutical preparations for such conditions as shock, exhaustion, migraine and heart ailments. The supply in recent years has been inadequate and as a result of the shortage the Monsanto Chemical Company has invested one and one-half million dollars in a plant for the synthetic production of caffeine. It is expected that the manufactured material will have a greater purity than the U.S.P. standards and that it will be more uniform in composition than the natural product. The present production in the United States exceeds 1 million pounds annually. It is expected that excess coffee, tea and cocoa will usually supply most of the caffeine but the new plant will prevent shortages.

Synthetic gum benzoin is now available in a form which is comparable in purity and price with the natural product which is obtained chiefly from Siam and Sumatra. It is used in medical practice as an expectorant and as an inhalation in laryngitis; industrially it finds wide use in the preparation of ointments, perfumery and cosmetics.

Another recent synthetic product is demerol, a substitute for morphine. It is a derivative of methyldiethanolamine. It has sedative, analgesic and antispasmotic effects and does not produce depression of the central nervous system.

The synthesis of quinine, identical with the drug which is extracted from cinchona bark, was announced in May 1944 by Drs. R. B. Woodward and W. E. Doering. This is a scientific triumph of no small proportions since for nearly a century chemists have been attempting to synthesize quinine. It is however by no means certain that the method will become important because of its cost as well as because of the success of the anti-

malarial campaign. This will be outlined under medicinals.

Methionine is an amino acid which has wide application in medicine, especially for treatment of the liver. The best natural sources are dairy products, fish and liver. A new process for the synthesis of this expensive substance has been announced by U. S. Industrial Chemicals. It is estimated that the new process will reduce the cost of methionine about 97% and make it available for the treatment of burns, shock, exposure, serious wounds, and for all types of poisoning in which the liver is involved. These include carbon tetrachloride, T.N.T., arsenic, phosphorus and chloroform.

The textile industries have shown remarkable advancement in numerous directions during the war years. These improvements have brought better usefulness from old fabrics, new fibers in the synthetic field and new chemical finishes by which both natural fibers and the synthetics are made more resistant to moisture, fire, mildew, moths, creasing and shrinkage. Not all of these problems have been solved completely, but progress has been made and continuing improvement is to be expected.

The age-old problem of the excessive shrinkage of wool has been partially solved by research conducted under the direction of the Quartermaster General. A goodly number of reagents (including mercuric acetate, benzoquinone, vinylidine compounds, amines, amino acids, and quaternary ammonium bases) have been found to be partially effective in controlling shrinkage, but the treatment must be varied in accord with the use which is to be made of the fabric. Particular success was accomplished in the preparation of shrink-proof socks for the army. At the end of the war 8 million pairs of socks were being treated each month. The increased life of the socks effected a saving which exceeded the entire annual cost of the research. Further developments in this field are to be expected for solving civilian problems.

Another interesting development in connection with the wool industry is the production in England of a new synthetic wool called ardil from the protein of peanuts after the oil has been extracted. This new fabric is soft and warm to the touch, does not shrink, is not attacked by moths and absorbs dyes and moisture as well as natural wool. Fine filaments of ardil are precipitated through a spinneret in much the same manner as rayon. The yield of ardil is said to be equal to a quarter of the weight of the peanuts used. The new "wool" is expected to be

cheaper than natural wool, but the process is not expected to displace the natural fabric.

When cotton fabric is partly acetylated it becomes resistant to mildew and rot by a process which has been developed at the Southern Regional Laboratory in New Orleans. The cloth is strong, is not discolored, is not toxic, and has no odor. The fabric will be useful in making tents, awnings, tarpaulins and fish nets. Another textile preservative is copper 8-quinolinolate, known commercially as milmer. It has been developed by the Monsanto Chemical Co. It is especially efficient in protecting against the fungi which produce rot.

Waterproofing is a process which has attracted attention for many years. The use of oils, waxes, resins, and other chemicals for coating the surface of fibers is not new. During the war it was found that the construction of the fabric had much to do with efficient water proofing. A combination of improved fabrics and better finishing material has given promising results, and more improvements are to be expected. The new water repellents include resins, derivatives of pyridine, urea, the silanes, and silicones.

The use of plastics in the textile industry is familiar but the applications have been greatly extended during the war. Sometimes a plastic material is added directly to the acetate spinning solution, thus producing greater resilience in the filaments. In another process plastic resins are used to bind together individual fibers, thus making unnecessary many of the steps in spinning and weaving. Bonded fiber webs of this type may be used in making filter cloth, table covering and artificial leather. The properties of the product are modified by the choice of resin and the structure of the fabric. When used as a finishing material resins decrease the tendency of fabrics to crease, increase the stiffening and resistance to laundering, prevent fraying and wool shrinkage and raise the temperature at which acetate rayon may be ironed with safety. Numerous new fibers are now produced from a variety of materials, such as cellulose, protein, starch, alginic acid, glass, polyamides, vinyl polymers and polyethylene. These present a great variety of desirable properties among them high strength, lightness, elasticity, resistance to heat and chemical and biological deterioration. Many of these will be splendidly adapted to specialized uses. Much attention has been given to the preparation of fibers which are suitable for blending with other materials.

Plastics had become established as a rapidly growing industry long before the outbreak of World War II. As long ago as 1920 the production of synthetic resins in the United States amounted to about 2 million pounds per year. The industry grew steadily in spite of business inflations and periods of depression. Roughly the output has doubled about once in three years. In 1944 the production was about 800 million pounds and it is predicted that the industry will continue to grow at about the same rate for several years. It has been estimated that the output of all plastic raw materials will be increased approximately 300% during the year 1946. The value of raw material, finished, molded, and fabricated products is expected to reach a billion dollars during the present year.

War time conditions stimulated research in the field of the plastics, although they did not influence the rate of production as much as they did in some other lines of activity. Developments were along two distinct lines. First, modifications, improvements and new applications of existing plastics. These changes include new plasticizers, developments in the field of injection molding and extrusion, coating wire and fabrics, impregnating paper, production of plastic foams and many others.

TABLE 1. PRODUCTION OF VARIOUS CLASSES OF PLASTICS IN MILLIONS OF POUNDS[1]

	United States		German
	1943	1945	1943
Vinyl chloride and copolymers	83	About 110	80
Polystyrene	4	15	16.0
Acrylates	70	—	61
Cellulose derivatives	87	100	22
Polyamides	20	—	16
Phenol resins	144	190	70
Urea resins	54	60	75
Vinylidene chloride and copolymers	2	—	(capacity) 1
Polyethylene	small	10	0.2
Chlorinated polyvinyl chloride	Experimental quantities only		10
Vinyl ethers	Negligible		10
Isocyanates	None reported		0.5
Polyvinyl carbizole	Started May 1943		small
Allyl resins	Growing military use		none

[1] This table is based on a report "Advances in Plastics in the United States and Germany," by W. C. Groggin Chemical and Engineering News, Feb. 10, 1946, 339–343.

Second, many new plastic materials have appeared on the market and have shown properties which commend them for special uses. Table I shows some of the more important classes of plastics, their production in the United States for 1943 and 1945 and for comparison the production in Germany in 1943, the last full year before disaster overtook the industry. The reports concerning the German industry were brought back by an intelligence team of the Quartermaster Corps.

Plastics from polyvinyl chloride and its copolymer are based upon the combination of acetylene and hydrochloric acid. These easily obtained materials are purified, then polymerized in emulsion and subjected to various fabrication steps. The product is useful for a wide range of applications including water proof fabrics, electrical tape, food wrappings, chemical piping, shoe soles, gloves and printing rolls. It is estimated that the United States will produce more than 1000 million pounds of these materials in 1946.

Polystyrene plastics were made in Germany by combining ethylene and benzene, forming ethylbenzene, which was cracked to give styrene. This was polymerized either by mass or emulsion methods. In both Germany and the United States the product was used for injection molding and making thin sheets and coatings. One modification in the form of rods can be machined to form special electrical insulators or polished for optical use. The production in the United States in 1946 is estimated at 150 million pounds.

Plastics of the acrylate type including lucite or plexiglas are widely used in molded or sheet form. Windows of airplanes, adhesives, coatings, thickeners, optical lenses, prisms and many other forms are made from this class of plastics.

Cellulose derivatives have been much more abundantly used in the United States than in Germany. Some recent improvements in this country include better production facilities, continuous extruding of cellulose ester sheeting and impregnating paper and cloth for wrapping materials, wall paper and window shades. It is estimated that the 1946 production of cellulose plastics in the United States will reach 80 million pounds, double the 1941 production. Germany produced a water-soluble cellulose derivative, carboxymethyl cellulose which was used as an extender for soap and synthetic detergents.

Polyamide plastics have been used largely for textiles and films. War time production included gas-proof clothing as pro-

tection against gas attacks, glider tow ropes, parachute fabrics and special moldings.

Phenolic resins have continued to hold the leading position in the United States, where developments include new specialties, resins designed for low pressure and contact pressure laminating and the use of high-frequency heating.

Urea resins are used mainly in adhesives for aircraft and furniture; some use is also made in molding processes. Melamin resins are useful in making electrical equipment. The vinylidene resins are useful largely for extruded bristles; window and door screenings have the advantage of long life and ease of cleaning. Chemical resistant pipes and fittings are likewise useful.

Of the resins which are more recent in this country the following show promise of increased usefulness. Chlorinated polyvinyl chloride gives chemical- and fungus-resistant yarn which is useful in making clothing, filter cloth, and military equipment. The vinyl ethers, only recently appearing in the United States, are useful as adhesives, in laminating preparations, and fabric coatings. Polyethylene, also quite new, is promising on account of its low cost and superior resistance to moisture, heat and electric charge. The isocyanates such as $R{\cdot}N{:}C{:}O$ and more complex compounds of this type react readily with substances containing free hydroxyls. Such reactions produce thermoplastic polyamide plastics, the development of which has been called "one of the most significant German advances during the war." These materials constitute a family of plastics which give promise of unusual usefulness in fibers, bristles, films and molding. Members of the family have high heat, abrasion, and chemical resistance, great strength, and are successful in making plastic foams. Polyvinyl carbazole promises to be useful in electric and electronic equipment. Allyl resins, developed in the United States, were mainly useful in military equipment for resistance to abrasion and for low-pressure laminating and casting.

Plastic foams were developed extensively in Germany. They are made by trapping a gas in plastic material as it solidifies. Three types were produced. (1) Air was whipped into a viscous mass as it became solid (used with urea-formaldehyde resins). (2) Liberation of a gas when the material is heated (used with vinyl-chloride and rubber). (3) Liberation of a gas (hydrogen or carbon dioxide) by interaction of components of a mixture (used with iso-cyanates or polyurethanes). The products are mainly used for insulation and for buoyancy in life boats and rafts.

A recent development in the plastic industry which may lead to greatly increased uses of these materials is the electrolytic deposition of various metals upon a plastic foundation. The surface is made conductive by the application of a thin layer of metal. This may be accomplished best by applying an easily reducible metallic solution like ammoniacal silver nitrate through adding a reducing agent. Other methods have been tried, such as painting the surface with a lacquer in which metal powder is suspended, metal spraying, or cathode sputtering. An intermediate layer of electrolytically deposited copper or silver may be added. The final layer of the desired metal (chromium, zinc, iron, lead, nickel, gold, silver or cadmium) may then be plated on. The metal-coated plastic is protected from weathering, oil, solvents, and moisture and it has increased strength and resistence to abrasion and heat. The metal coating does not corrode as rapidly as it does when applied to a base metal because of the absence of electrolytic action.

Synthetic rubber resembles the plastics in that it is made by condensation and polymerization, resulting in building up enormous molecules from relatively small molecular structures. The term is applied to a wide variety of rubber-like materials (elastomers) which resemble natural rubber in physical properties but differ from it in chemical composition. Many types of such material have been produced. The four which have survived commercial competition most successfully are shown in Table 2. Other varieties are still available for special uses. None of the synthetics has the general all-around usefulness of natural rubber, but each has some particular property in which it excells the natural product. So by varying the composition or treatment of the various elastomers, they may be made to furnish keen competition for natural rubber. More than 250 variations of GR-S have been produced on a commercial plant scale and more than a dozen types are in regular production.

Little attention was paid in the United States to the development of synthetic rubber until the sudden outbreak of World War II shut off nearly the entire supply of natural rubber. When this emergency arose there was on hand a small stock pile (about 600,000 tons), a scant prewar year consumption. Efforts to supply the deficiency were along three lines: (1) increased supply of natural rubber as from Central and South America and Africa; (2) new sources of supply such as guayule, cryptostegia grandiflora, goldenrod, dandelion and castilloa; (3) intense activity in the manufacture of synthetic rubbers of various types.

Buna S, the most important synthetic, is made by the copolymerization of butadiene and styrene. It is characterized by poor resistance to chemicals and oil but excellent behavior to abrasion. It vulcanizes well and is the best synthetic for tires.

TABLE 2. RUBBER SUPPLY AND CONSUMPTION IN THOUSANDS OF LONG TONS[1]

	GR-S (Buna S)	GR-I (Butyl)	GR-M (Neoprene)	N Types	Total Synthetic	Reclaimed Rubber	Natural Rubber	Grand Total
1944								
Production and imports	680	20	57	17	774	261	108	1.112
Consumption and exports	595	11	52	15	672	263	154	1.089
1945								
Production and imports	720	52	46	8	830	243	137	1.210
Consumption and exports	677	44	48	9	777	254	112	1.143

[1] Condensed from Chemical and Engineering News, Feb. 10, 1946, p. 336.

The early products were more expensive (about 15%), required a longer time for vulcanization, needed to have a substantial admixture of natural rubber and failed more quickly in service than tires from natural rubber. These handicaps have been largely overcome within the last two years and, at present, synthetic tires are considered equal in service to the natural products on passenger cars, though still inferior on trucks and buses, on account of the greater heat generated by the heavier vehicles. In May, 1946, GR-S was quoted at 18.5 cents per pound and natural rubber at 22.5 cents.

Butyl (GR-I) rubber is made from materials recovered from refinery gases such as isobutylene (about 98%) and isoprene (about 2%). It is made by a continuous process from former waste materials, so is one of the least expensive synthetic rubbers. Its chief characteristics are impermeability to air and resistance to ozone and chemicals. In the judgment of some, it is now to be regarded as the most satisfactory material for inner tubes.

Neoprene, made from vinylacetylene, has marked resistance to the effect of oil, chemicals, air, heat and abrasion. It sold for over a dollar a pound in 1931 (its first year) but in 1943 it was priced at 45 cents per pound. It is used in the manufacture of

airplane hose, self-sealing fuel tanks, life saving devices and gas masks.

Perbunan (Buna N) is made by the copolymerization of butadiene and acrylonitrile in aqueous emulsion. By varying the proportions in the mixture the properties of the finished product may be varied. During the war perbunan was used almost entirely in military or naval aircraft for self-sealing fuel tanks, gaskets, cable covers and similar purposes. It has been predicted that it will find numerous civilian uses in household and industrial utensils. It has been called "the synthetic rubber of a hundred uses."

The anticipated rivalry between natural and synthetic rubber has begun. There have been difficulties in the production of natural rubber and its higher cost has served to stimulate the use of the synthetic material. Intensive research is continuing in the field of synthetics, with the purpose of correcting the undesirable characteristics and increasing the properties in which there is an advantage. It is likely that this wide versatility will permit the synthetic industry to continue especially for the production of rubbers for special purposes. But the effect of competition is already evidenced by the closing of all butadiene plants which used alcohol as a raw material and of some of the more expensive plants whose methods were based upon petroleum products.

(*To be continued*)

TWO TYPES OF PUPILS

We see on every hand a substitution of the *easy* way for the *better* way. Parents find it *easier* to shift their responsibilities on to the school. School administrators, faced with this lack of cooperation, find it *easier* to let down standards. High schools find it *easier* to substitute unreliable "local" tests for Regents examinations. Teachers find it *easier* not to require careful work and high standards of achievement.

Mind you, we are not saying that the aims and standards of the schools are not in need of change. There are thousands of pupils who would profit little, and lose much, in attempting to pass Regents examinations in science like those of recent years. These pupils just do not have what it takes to comprehend the subjects that well. For them courses must be modified and requirements lowered, although they still must be held to standards that are not a farce. But for those pupils who have the ability to meet high standards, to require anything less is sheer stupidity.

Yes, we must change our standards and lower them where necessary. But an indiscriminate lowering of standards—and this seems to be what some science teachers are asking—would be a serious blunder.

The Science Teachers Bulletin

FACTORING LARGE NUMBERS

ORVILLE FOWLER BARCUS
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This article on a method for finding the factors of any number may be of interest to many readers.

My method follows. Let us take as a number, 3403 of which we are to find the factors. 3403 can be written as 59^2-78, or as the difference of squares $62^2-21^2=(62+21)(62-21)=83\times 41$ which are the required factors. The problem consists in finding what number (n) shall be added to 59, making a corresponding number of the form $n^2+2(59)n$ to be added to the 78 to make the form 62^2-21^2.

Now it can be shown that

$$2n=\frac{a^2-78}{59-a}=\frac{b^2-78}{59+b}=b-a=\frac{ab-78}{59} \tag{1}$$

where the two denominators $(59-a)$ and $(59+b)$ are the required factors of the given number 3403. By trial we find when $a=18$ and $b=24$, $2n=6$ and $n=3$. Adding 3 to 59 in the form 59^2-78 and we get 62. Adding 363, (n^2+118n), to 78 and we get $441=(21)^2$.

Our problem consists in deriving values for "a" and "b," and hence for "n," in equation 1.

Another method, which is also a cut-and-try method consists as follows. Write 3403 as $59^2-\ \ 78$

$$\begin{array}{rll} \text{Then add} & 119=2(59)+1 & \\ \hline & 60^2-197 & \\ & 121 \rightarrow & \text{increasing by 2 each} \\ \hline & & \text{added number un-} \\ & 61^2-318 & \text{til a perfect square} \\ & 123 & \text{is arrived at.} \\ \hline & 62^2-441 & \end{array}$$

$$=62^2-21^2=(62+21)(62-21)=83\times 41$$

Of course in handling real large numbers the difficulty consists in recognizing numbers, such as 441, as perfect squares. Here again we can write the equation:

$$n^2+118n+78=(n+r)^2 \tag{2}$$

where the problem consists in finding a value for "n" that will make the expression $n^2+118n+78$ a perfect square. Solving equation 2 for n and we have;

$$(3) \qquad n=\frac{1}{2}\ \frac{r^2-78}{(59-r)}$$

from which, by substituting proper values for "r" we can get a whole number value for "n." We find that when $r=18$, $n=3$ which is the number that must be added to 59 to get the required 62. If we subtract 18, ($r=18$), from 59 we get 41 which is one of the factors of 3403.

The problem of finding factors of numbers by this method consists in solving for "n" in equation 1.

If we solve for "a" in terms of "b" in equation 1

$$\frac{b^2-78}{59+b}=b-a$$

we find

$$(4) \qquad a=\frac{59b+78}{b+59}\cdot$$

By our old cut-and-try method we find that when $b=24$, we get $a=18$, making our factors of the given number 3403

$$59-a=41$$

$$59+b=83.$$

It does seem that there must be some mathematical "tool" enabling us to solve any one of the foregoing four equations, whereby the required factors may be derived.

Example: Factor the number 126,509.

We have $126{,}509=356^2-227$.

Whence

$$2n=\frac{a^2-227}{356-a}=\frac{b^2-227}{356+b}=b-a=\frac{ab-227}{356}\cdot$$

By trial we find that when $a=283$, $n=547$ changing the expression

$$356^2-227 \text{ to } (356+547)^2-[547^2+712(547)+227]$$

$$=(903)^2-(830)^2$$

$$=1733\times 73 \text{ the required factors.}$$

Or simply, $356-283=73$ one of the factors.

Sometimes a comparatively small factor of a large number, such as 126,509 may be found as follows.

$$
\begin{array}{rrl}
126{,}509 = & 356^2 - 227 & \\
\text{add} & 713 & [2(356)+1] \\
\cline{2-2}
 & 357^2 - 940 & \\
 & 715 & \\
\cline{2-2}
 & 358^2 - 1655 & \\
 & 717 & \\
\cline{2-2}
 & 359^2 - 2372 & \\
 & 719 & \\
\cline{2-2}
 & 360^2 - 3091 & \\
 & 721 & \\
\cline{2-2}
 & 361^2 - 3812 & \\
 & 723 & \\
\cline{2-2}
 & 362^2 - 4535 & \\
 & 725 & \\
\cline{2-2}
 & 363^2 - 5260 & \\
 & 727 & \\
\cline{2-2}
 & 364^2 - 5987 & \\
 & 729 & \\
\cline{2-2}
73\,| & 365^2 - 6716 & n^2+2(356)n+227 \quad [n=9] \\
\cline{1-2}
 & 5(365) - 92 & (\text{possibility})
\end{array}
$$

Showing that 73 is a factor of 126,509.

Some mathematical expression might be found showing what must be added, for example, to 356 in the above example to arrive at the numbers 365 and 6716 both of which contain the required factor, 73.

Inspecting the above set-up we find that the expressions 357^2-940 and 363^2-5260 are the ones giving possible solutions since the others do not give integral square numbers for the

second term in the set-up. If we wished to continue this method it would be necessary to advance by 10's, for 357^2-940 and 363^2-5260, and of course we should eventually arrive at the set-up $903^2-688900$

$$=903^2-830^2$$
$$=(903+830)(903-830)$$

for the factors of 126,509.

Of course, the problem here is to find what number must be added to 363 in the set-up 363^2-5260 in order to arrive at the set-up $903^2-688900=903^2-830^2$.—The number (n) being equal to $(903-363)=540$ in this case.

[Note: It will always be found that if a number (as in the set-up 363^2-5260) ends in say a "3" then the other set-up will have a number in the set-up 357^2-940 ending in "7" or the complement of "3".]

TELESCOPE PRESENTED TO HARVARD UNIVERSITY

The large Bausch & Lomb Optical Co. telescope, for more than 30 years a Rochester landmark, today became an outright gift to Harvard University.

Constructed in 1912 and used by thousands of visitors at the observatory located atop the company's six-story building on St. Paul Street, the telescope will be installed in the High Altitude Observatory at Climax, Colorado. The Colorado observatory, astride the Rocky Mountain Divide, is the highest in the world. More than 11,000 feet above sea level, it is operated jointly by Harvard and Colorado Universities.

Dr. Donald H. Menzel, Harvard Observatory, will be in charge of installing the telescope sought after by the Colorado astronomers now probing new mysteries of the sun. On a recent visit to the Bausch & Lomb plant, Dr. Menzel termed the 17-foot, one-ton telescope as "ideal" for the studies now underway at the Colorado observatory.

By use of a device known as a coronagraph, which produces an artificial eclipse of the sun's fiery edge, scientists are able to make minute analysis of gaseous flames. Recently it was shown that radio static disturbances have a direct relationship to the gas clouds hurtling from the sun's surface which play hob with radio.

The telescope, fitted with special filters, will be used primarily for studies of the solar disk, including sun spots. An attached motion picture camera will record the rapid changes occurring in the solar atmosphere.

L'INFORMATION DES SCIENCES PHYSIQUES

Vol. 1, No. 1, January–February of this new journal came out early this year. It is put out by J. B. Failliere & Sons, 19, rue Hautefeuille, Paris (6^e). France 200 fr. Foreign 250 fr.

pH AND HYDROGEN-ION CONCENTRATION CALCULATIONS

C. J. Schollenberger

Wooster, Ohio

A note on the relation between pH and hydrogen-ion concentration which appeared in a recent number of *The Chemist-Analyst* (1) did not explain the subject in the simplest possible manner, nor offer any help in solving related problems to those unfamiliar with the methods of calculation.

In the symbol pH, the lower case p indicates that the number following is the logarithm of a reciprocal and the capital H indicates that the hydrogen-ion concentration is under consideration. The same convention applies in other expressions used in pH calculations, viz., pOH, pK_w, pC, pK_a and pK_b, meaning respectively the logarithm of the reciprocal hydroxyl-ion concentration, ion product constant of water, molar concentration and the dissociation constants of an acid and a base. The logarithm of the reciprocal of a number is simply the logarithm of the number with sign reversed. For the values mentioned, the numbers considered are in practically all cases less than unity, hence their logarithms are negative. It is convenient to omit the negative sign and this is the reason for using the reciprocals.

Calculation with logarithms is very simple—the rules are given with most tables, and likewise the explanation that the values in the tables are merely mantissas and are *positive*. The latter point may be overlooked or forgotten by the student, who may then find himself in difficulties. There is in general use and still taught in connection with logarithms the expedient of adding algebraically positive 10 (or a multiple of 10) to a negative characteristic and then indicating the subtraction of the same from the positive mantissa. This is supposed to save time and effort in dealing with negative logarithms. But neither the mixed form, e.g., $\bar{6}.184$, which would first be written after determining the value of the characteristic and taking the mantissa from a table, nor the form $4.184-10$ into which it would be converted, is used in connection with pH etc. For this, there is required the wholly negative form -5.816. The conversion of a mixed to a wholly negative logarithm (and the reverse change) is readily done by inspection according to the following rule:

Decrease (increase) the numerical value of the negative characteristic by one; in either case, subtract each successive figure of the

mantissa from 9 until the last, which is subtracted from 10.

The foregoing is easily remembered and the operation can be performed as rapidly as the figures can be written down. This is merely an easy means for making by inspection the subtraction required to find the true value of a logarithm written with negative characteristic and positive mantissa (or of making the reverse change when the wholly negative logarithm is known). It is useful in solving problems like the following:

What is the pH value represented by the expression $[H^+]=2.14\times 10^{-5}$? The logarithm corresponding is the sum of the logarithms of the two factors; the logarithm of 10^{-5} is -5 and that of 2.14 is shown by a table to be 0.33, a positive value so we write $\bar{5}.33$ and then apply the rule to get the wholly negative value -4.67. The pH value is therefore 4.67.

What is the hydrogen-ion concentration corresponding to pH 9.26? The wholly negative logarithm -9.26 is converted to the form $\overline{10}.74$, in which the mantissa is positive (according to the rule). This mixed logarithm can be considered the sum of the logarithms -10 and 0.74. Reference to a table shows that the antilogarithm of the latter is 5.5, so the answer is 5.5×10^{-10}.

Tables of dissociation constants of acids and bases in some texts show values as pK_a and pK_b instead of as the more usual powers of 10. Thus, for acetic acid with dissociation constant $K_a=1.86\times 10^{-5}$, pK_a is 4.73. The latter form is of greater practical use and is more convenient for simple calculations. For example, pK_a of a weak monobasic acid such as acetic is approximately the pH value at half neutralization by a strong base. At this point the solution will have maximum buffering power, and the latter will be good in the range $pH=pK_a\pm 1$. The pH value at any stage of a partial neutralization similar to the foregoing may be calculated:

$$pH=pK_a+\log\frac{\text{salt concentration}}{\text{acid concentration}}\,.$$

The optimum endpoint pH for titrating a weak acid is at pK_a+2, according to Britton (2); an indicator with a pronounced color change at that point should be selected.

The approximate pH values of dilute solutions of weak monobasic acids can be calculated by a formula (2, 3)

$$pH=\tfrac{1}{2}pK_a+\tfrac{1}{2}pC$$

pC is the wholly negative logarithm of the normality with sign

reversed, i.e., considered to be positive. For weak bases such as ammonium the treatment is similar, but of course with consideration of pOH and remembering that $pH = 14 - pOH$; the 14 in this formula is the numerical value of pK_w. With polybasic weak acids having the first hydrogen much more dissociated, an approximate value is secured by considering only the pK of this first hydrogen, and C then represents molar concentration as with a monobasic acid.

The pH of a hydrolyzing salt solution may be calculated:

(a) A salt of a weak acid and a strong base, e.g., sodium acetate.

$$pH = \tfrac{1}{2}pK_w + \tfrac{1}{2}pK_a - \tfrac{1}{2}pC$$

(b) A salt of a strong acid and a weak base, e.g., ammonium chloride.

$$pH = \tfrac{1}{2}pK_w - \tfrac{1}{2}pK_b + \tfrac{1}{2}pC$$

(c) A salt of a weak acid and a weak base, e.g., ammonium acetate.

$$pH = \tfrac{1}{2}pK_w + \tfrac{1}{2}pK_a - \tfrac{1}{2}pK_b$$

pK_w is the logarithm of the ion product constant of water, -14.0, with sign reversed; $\tfrac{1}{2}pK_w$ therefore has the numerical value 7 at 25° C. The value of pK_w is affected by temperature; in the range 0–40° C., at t° C.

$$pK_w = 14.926 - 0.042t + 0.00016t^2.$$

pH is supposed to represent the activity rather than the concentration of the hydrogen-ions in a solution. Since ionic activity is affected by the presence of other ions, of the same or different species, pH is not unaffected by neutral salts in solution, and such influence varies with the valence of the ions as well as their concentration. These factors are collected in a value called the ionic strength (u), the sum of the products of the concentration and square of the valence of each ion, divided by the number of ionic species.

$$u = \frac{c_1v_1^2 + c_2v_2^2 + \cdots + c_nv_n^2}{n}.$$

For example, in the bicarbonate-carbonic acid system,

$$pH = pK_1 - 0.5\sqrt{u} + \log\,[HCO_3^-] - \log\frac{aP_{CO_2}}{22.4}$$

wherein pK_1 has the value 6.4 and represents the first dissociation constant of carbonic acid, a is the absorption coefficient of CO_2, 0.759 at 25° C., and P_{CO_2} is the partial pressure of carbon dioxide in the gas at equilibrium. It is seen that the effect of the factor u is to decrease pH, therefore neutral salts can increase the actual acidity; the actual acidity increases with titrable alkalinity, because the latter is due to an acid salt, the bicarbonate. In this and other formulas, log means the logarithm with its proper sign, not reversed; the form to be used is -1.57, for example.

References

(1) Batson, D. M., and Frances O. Batson. 1945 A simple method for conversion of fractional *p*H values, *The Chemist-Analyst*, 34, 54–56.

(2) Britton, H. T. S. 1932, Hydrogen-ions. Their determination and importance in pure and industrial chemistry, D. Van Nostrand & Co., Inc. New York.

(3) Kolthoff, I. M. 1931, The colorimetric and potentiometric determination of *p*H, John Wiley & Sons, Inc. New York.

NEW FACULTY MEMBERS AT EARLHAM COLLEGE

Dr. David Telfair, former research physicist with the Monsanto Chemical Company, and Joachim Jaenicke, former teacher at Westtown Friends School, Westtown, Pa., will become members of the Earlham college faculty next fall, it was announced by President Thomas E. Jones.

Dr. Telfair, a graduate of Earlham in 1936, will teacher higher mathematics and will assist Dr. George D. VanDyke in the physics department. Mr. Jaenicke will teach history.

Mr. Jaenicke was born in Germany 33 years ago and spend the first 18 years of his life there. His father was for eleven years governor of Lower Silesia, and later a member of the Reichstag. In 1933 he resigned his position and went as a League of Nations advisor to the Chinese National Government, and Mr. Jaenicke received his high school training in Shanghai. In 1935, the elder Mr. Jaenicke and Mrs. Jaenicke returned to Europe, but because of the political situation in Germany, they lived in complete retirement in southern Germany. At the present time, the elder Mr. Jaenicke is again active, serving as State Commissioner for refugees, responsible for the settlement in Bavaria of a million and a half Germans expelled from eastern Europe.

The younger Mr. Jaenicke, who did not return to Germany with his parents, studied in France, at Geneva, Switzerland, and at The Hague. He also did research work in Paris.

In 1939 he came to America, where he studied at Haverford college, and later at the Fletcher School of Law and Diplomacy at Medford, Mass. Since 1941 he has been a teacher at Westtown Friends School, teaching German, French, and History.

THE PHOTOELECTRIC COLORIMETER IN GENERAL CHEMISTRY

Sister M. Ignatia

Marygrove College, Detroit, Michigan

The advantages of the photoelectric colorimeter over the Du Boscq type in the biochemistry course for undergraduates have already been pointed out.[1] In addition to using the photoelectric colorimeter in the physiological and organic chemistry courses for the quantitative determination of such substances as glucose, we have found that a simple experiment in which this instrument is used to determine the concentration of a colored solution is a valuable addition to the course in general chemistry.

After the usual experiments introducing the students to solutions and titration, we showed them the construction of an industrial type of photelometer, the proper technique for its use and a simple explanation of the theory involved. Mimeographed sheets summarizing these points and giving directions for the experiment to be performed were given to the students. In this experiment they used colored salts of sufficient solubility, semi-quantitative balances, 50 milliliter volumetric flasks, and volumetric pipettes of the proper size to make up three solutions of known concentration—for example, one, four-tenths, and one-tenth normal. The transmittances of these solutions were determined by means of the photelometer, and the logarithms of the transmittances were plotted against the concentrations on ordinary graph paper. The "best fitting" straight line was drawn in on each graph and was used to determine unknown concentrations of solutions of the same colored salt for which the graph was made.

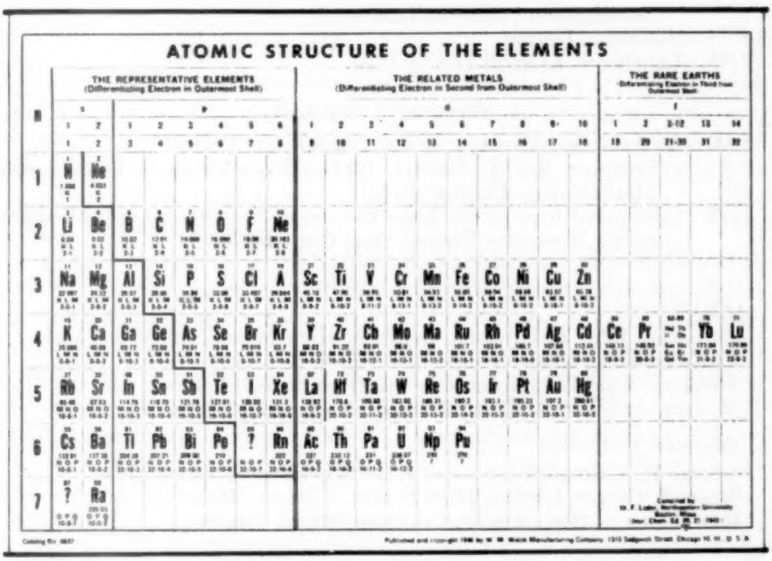
Had the students not been beginners, semi-logarithmic paper would have been used, but looking up the logarithms and using them in the graph increased the students' respect for a tool that is too often considered by them to be "merely mathematics." To further increase this respect, the students were required to plot the transmittances in galvanometric units against the concentrations. The absence of any straight line tendency showed the difficulty that would be encountered if they attempted to disregard logarithms.

[1] Sumner, James B., "The Photoelectric Colorimeter," *Journal of Chemical Education*, 20, 510 (1945).

In spite of its simplicity this experiment goes far toward making the students "instrumental minded," and it drills techniques that are valuable in industrial laboratories. Since we want as many as possible of our chemistry majors to have the experience of summer work in commercial laboratories, is it not wise to include such an experiment in the course in general chemistry?

CHART OF ATOMIC STRUCTURE OF THE ELEMENTS

This chart is based upon the concept of the "Differentiating electrons." If we assume that one atom can be built up from the preceding one by adding one electron each time the nuclear charge is increased by one unit this additional electron is called the differentiating electron. Each atom is thus placed on the chart according to the position of its differentiating



electron. There are, therefore, three groups of atoms:—1. the differentiating electron in the outermost shell, 2. the differentiating electron in the second from the outermost shell and 3. the differentiating electron in the third from the outermost shell.

The two new artificial elements of Np and Pu are included in this chart.

The chart was compiled by Professor W. F. Luder of Northeastern University, Boston, Mass., and was written up in *Journal of Chemical Education*, 20, 21 (1943).

Printed in three colors on heavy reinforced chart stock 42×58 inches, with double split rollers at top and bottom.

No. 4847. Chart of Atomic Structure of the Elements, $5.00. W. M. Welch Manufacturing Company, 1515 Sedgwick Ave., Chicago 10, Ill.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED SIXTY-SECOND MEETING

College of the Holy Cross
Worcester, Massachusetts
Saturday, May 11, 1946

MORNING PROGRAM

10:00 Address of Welcome, Reverend William J. Healey, S.J., Ph.D. President of the College of the Holy Cross.

10:15 Address: By-products of Seismology. Reverend Daniel Linehan, S.J., Assistant Director of the Weston Seismological Laboratory.

11:15 Address: Dynamic Illustration of the Gas Laws by Shadow Projection. Reverend Bernard A. Fiekers, S.J., Chairman of the Chemistry Department, College of the Holy Cross.

12:15 Address: Mr. Albert Thorndike, Vice-President of the Eastern Association of Physics Teachers.

12:25 Business Meeting.

1:15 Luncheon: Kimball Dining Hall.

AFTERNOON PROGRAM

2:00 Address: Spectroscopy in the Liberal Arts College. Professor Roy C. Gunter, Ph.D., Department of Physics and Mathematics, Clark College.

3:15 Conducted tour to the John Woodman Higgins Armory Museum at the Worcester Pressed Steel Corporation.

Officers:

President: John T. Gibbons, Brighton High School, Brighton, Mass.
Vice-President: Albert Thorndike, Milton Academy, Milton, Mass.
Secretary: Carl W. Staples, Chelsea High School, Chelsea, Mass.
Treasurer: Albert R. Clish, Belmont High School, Belmont, Mass.

Executive Committee:

George H. Colman, Gloucester High School, Gloucester, Mass.
James J. Cotter, Chelsea High School, Chelsea, Mass.
Edwin Sawin, High School, Cranston, Rhode Island

BUSINESS MEETING

The following were elected to active membership:
Philip Audibent, Rockville High School, Rockville, Conn.
Lillian S. Blomstrom, South High School, Worcester, Mass.
Edward J. Galvin, Taunton High School, Taunton, Mass.
Ralph Huntley, Pomfret School, Pomfret, Conn.
Chandler D. Ingersoll, Admiral Billard Academy, New London, Conn.
Edwin C. Miller, Naugatuck High School, Naugatuck, Conn.
Carl W. Perkins, Fitchburg High School, Fitchburg, Mass.
Jack H. Semon, Simsbury High School, Simsbury, Conn.
Horace A. Sherman, St. Paul's School, Concord, N. H.

REPORT OF NOMINATING COMMITTEE

The Nominating Committee have submitted the following list for the coming year:

President: John T. Gibbons, Brighton High School, Brighton, Mass.
Vice-President: Anna E. Holman, Winsor School, Boston, Mass.
Secretary: Albert Thorndike, Milton Academy, Milton, Mass.
Treasurer: Albert R. Clish, Belmont High School, Belmont, Mass.
Executive Committee:
Raymond F. Scott, Rindge Technical School, Cambridge, Mass.
Clarence W. Lombard, Hyde Park High School, Hyde Park, Mass.
Mrs. W. Wallace Matheson, Cambridge Latin School, Cambridge, Mass.

Louis R. Welch, Chairman.

The above-named were elected officers for the coming year.

BY-PRODUCTS OF SEISMOLOGY

Daniel Linehan, S.J.

As the science of geophysics expands with the other sciences, it no longer belongs to the geophysicist alone, but is spreading into other fields. The geologist, the aviator, the road builder, are some who have found it a necessary aid; the mining, civil, hydraulic, petroleum, and other engineers have found this science an essential in their own work. There are others as well, but we feel that the physics teacher, especially, would find a great field of interest in geophysics.

Seismology, from the etymology of the word, is the study of vibrations, and is a branch of geophysics. In seismology the physicist may find almost every branch of physics being used or demonstrated. Elasticity, density, wave motion, sound, polarization, electromagnetics, meteorology, electronics, hydrodynamics, energy, mass, Laws of motions, inertia—indeed every page of the physics text-book contains terms that are the daily language of the seismologist. Once the seismologist was bound tightly to the study of earthquakes alone, but today he is working in fields that seem to have little if any connection with earthquakes. We have titled these fields, for this paper, the "By-Products of Seismology."

In a former paper to this society[1] were explained the causes of earthquakes, their place of occurrence, and the method of studying them. Mentioned, too, were a few of the by-products, but in this paper we would like to spend more time on these latter products and add a few that have developed since the beginning of the War.

For a complete understanding of seismology and the analysis of earthquakes, the reader is referred to the above paper. Let it suffice to review here that an earthquake generates three types of waves through the earth, a longitudinal, a transverse, and a gravity or surface wave. The velocity of these waves depend upon the characteristics of the medium transmitting

[1] "School Science and Mathematics," Vol. XLI, No. 2, Feb. 1941, pp. 188–194.

them. Naturally, by studying the velocities the seismologist may argue back to the type of material. Likewise, the reflections, refractions, and the polarization of these waves, will lead to a greater knowledge of the earth's interior.

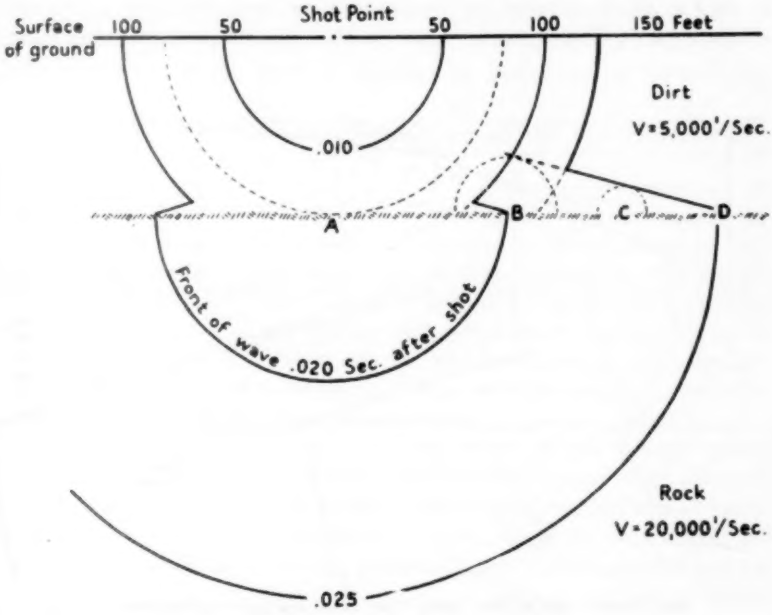
The seismograph, as was mentioned in the former paper, has as its fundamental principle for measuring earth motion, the pendulum, and from this, by varying means, some method of transducing the earth motion onto a record. The magnification factor may vary up to several thousands of times or even to some hundred of thousands of times, as found in Stations as Harvard University, California Institute of Technology, Weston College and others. In field seismology, where electronic amplification is used, magnifications of a million times or more are common.

As we have said, waves from an earthquake or other disturbance in the ground, teach us something about the transmitting material. Sand, for example, transmits sound at 2,000 ft/sec; gravels, about 4,000 ft/sec; varved clays at 5,000 ft/sec; clay-gravels, known locally as "hard-pan," at 8,000 ft/sec; bedrock, depending on the type, vary from 10,000 to 30,000 ft/sec. Likewise, for a given rock, its structure may at times affect the velocity by some 70% or more, depending upon the anisotropic features of the structure. Hence the type of rock or sediment may be determined by discovering the velocity of sound in that material. This may be done even though hundreds of feet of other material may cover the material under study.

The common method of measuring such velocities employs several seismographs spaced at definite intervals from a shot point, or source of sound. This latter is the little earthquake the seismologist uses, and he utilizes an explosion of dynamite or some other explosive, the amount varying with the problem. When the shot is fired the waves passing through the ground or rock register on each seismograph in line, this registration in turn travels by wire to a recording camera where the registrations of all seismographs are recorded on a single record. In like manner the instant of shot is also recorded on the same record. Time marks on the record permit reading to the closest millisecond (.001 sec). Knowing the moment of shot, the reception at each instrument, one may easily determine the velocity by plotting the time against the reception distance. From some of the accompanying figures, we may see to what other uses the seismologists puts these known velocities.

Diagram #1 represents approximately 80 feet of dirt, in which the fastest wave, the longitudinal or sound wave, travels 5,000 ft/sec. Below the dirt is bedrock in which the velocity of the same wave is 20,000 ft/sec, with the rock parallel to the ground surface. Under these conditions, the wave front will be a sphere of 50 ft. radius 10 milliseconds after it leaves the shot point. This is represented in Fig. #1 by the circle marked ".010." 16 milliseconds after the shot, the wave front reaches the rock at 'A.' From this point of contact, a wavelet starts into the rock with a new speed of 20,000 ft/sec. 20 milliseconds after the shot this wavelet reaches a point on the

curve marked ".020," vertically below '*A*'. Meanwhile, other such wavelets enter the rock in a continuous series as the disturbance in the overlying dirt rolls down against the dirt-rock boundary. In the interval between the time it entered the rock and the 20th millisecond following the shot, each of these wavelets travels as far as it can at 20,000 ft/sec. At the 20th millisecond then, the envelope of all these wavelets constitutes the wave front in the rock, which is shown in Fig. #1. This is not a sphere, and it has outrun the wave in the dirt so that it is the first disturbance to reach such a point as '*B*,' on the dirt-rock interface. As the rock-wave passes '*B*' at



SUCCESSIVE POSITIONS OF FRONT OF DISTURBANCE IN A TWO-LAYER REGION

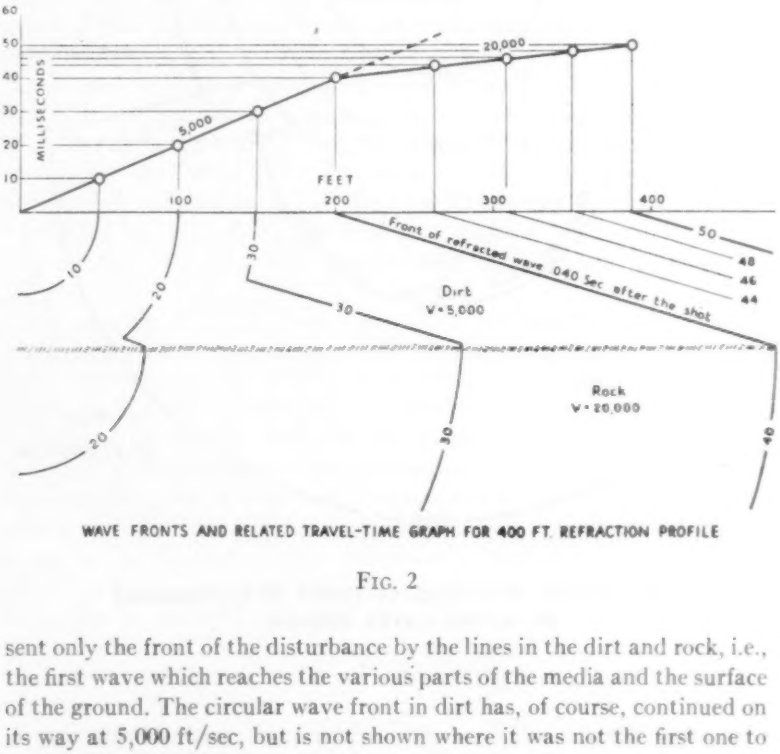
FIG. 1

the instant .020, it starts a wavelet in the dirt. The position of this wavelet at the instant .025 is shown by the dotted circle in Fig. #1. Like dragging a stick through water the wave advancing in the rock along the rock-dirt boundary sets up a continuous series of wavelets in the dirt. It is quite similar to the generation of a "bow wave" in water or air. Another started as the rock-wave passed '*C*,' is shown at the instant .025 by a dotted circle. The envelope of the wavelets, of which '*B*' and '*C*' are isolated examples, constitutes part of the wave front 25 milliseconds after the shot. This part is a plane front, the wave refracted back into the dirt and is

shown as a straight line in Fig. #1. The angle which this front makes with the dirt-rock interface is controlled by the ratio of the dirt-rock velocities and is the same whether the rock is parallel to the ground surface or not.

Accordingly, 25 milliseconds after the shot, the front of the advancing disturbance consists of three segments; (1) part of the original circular and direct wave front in dirt; (2) the plane front of the refracted wave; (3) the curved front penetrating the rock and traversing the dirt-rock boundary. In Fig. #1 the first disturbance to reach points along the surface of the ground throughout the interval is the direct wave which has travelled only in dirt at 5,000 ft/sec.

In Fig. #2, is pictured the continued advance of the front of this disturbance until 50 milliseconds after the shot. For simplicity we shall repre-



WAVE FRONTS AND RELATED TRAVEL-TIME GRAPH FOR 400 FT. REFRACTION PROFILE

FIG. 2

sent only the front of the disturbance by the lines in the dirt and rock, i.e., the first wave which reaches the various parts of the media and the surface of the ground. The circular wave front in dirt has, of course, continued on its way at 5,000 ft/sec, but is not shown where it was not the first one to reach a given position.

200 feet from the shot point the direct wave in the dirt and the refracted wave arrive at the same time, 40 milliseconds after the shot. Beyond that distance, the refracted wave is the first to reach the surface stations.

In Fig. #2, the wave front pattern is accompanied by a graph on which are plotted the arrival times distances to 400 feet from the shot. Short of

200 feet these times fall on a line the reciprocal slope of which is 5,000 ft/sec, the speed of the wave in dirt. Beyond 200 feet, the arrival times fall on a line, showing a velocity of 20,000 ft/sec, the speed of the wave in rock. The distance at which these two lines intersect is controlled by the thickness of the dirt cover. A greater thickness than that chosen for the illustration would result in intersection of the two lines at a greater distance from the shot.

Using the velocities and the distance of intersection of the velocity lines, the seismologist may easily determine the depth of dirt or cover over any rock. Indeed, he does not need to know beforehand what the rock is, or what the cover is, as he will determine these velocities in the field. If d = distance of intersections; V_1 = the velocity of the dirt; V_2 = velocity of the rock; then 'h,' the depth of dirt may be determined by the following formula:

$$h=\frac{d}{2}\sqrt{\frac{V_2-V_1}{V_2+V_1}}$$

or in this problem $h = 100$ ft $\times 0.77$ or 77 feet depth.

Employing seismology in such a manner to determine depth of rock etc., is known as the "Seismic Refraction Method." This is the method used most commonly by Weston College in geophysical studies in and about New England. It is accurate in areas where the cover is shallow. The above formula, is the simplest possible to use, and in this paper represents but one geological problem to be solved. There are other formulae and other methods used depending upon the problem.

Another general seismic method is that known as the "Seismic Reflection Method." For certain problems, this method is more rapid, cheaper, and frequently lends itself to easier computation. It is used almost exclusively in the Petroleum Exploration Industry where the data sought are usually at great depths below the surface. Depths less than a 1,000 feet are difficult to work with following the reflection method, but greater depths are usually quite simple. This method employs the principle of timing the echo of the waves from the shot to some reflecting stratum and its return. A profile surveyed in this manner yields a great deal of data on the depth, dip and surface conditions of the reflecting material.

Petroleum is stored in certain rocks, or sediments, at varying depths below the earth's surface. These rocks are porous to the extent of allowing the oil to flow or seep through the rock or stratum, but the oil may be held within this layer by an overlying stratum that is impervious to oil flow. The oil bearing rock may be perfectly level, or it may rise to a dome-like formation, or even rise to a certain point, be there cut off by faulting and the end sealed by some other impervious layer. A driller could drill a well at any point in a petroleum region and strike oil at a certain depth, but the yield might be only a few barrels a day. If he should strike into a dome or a sealed end of a rise, he would drill into a reservoir of oil that would more than pay for his drilling operations. It is the problem of the seismolo-

gist to find these domes or rises. One method is to begin a reflection survey near a well where the depth to a certain stratum may be determined, then start cross-country studying the reflections, and looking for places where his records tell him a dome exists or some other rise. These locations will then be surveyed in detail, and the structures outlined before any drilling is done. The importance of seismic work in the Petroleum Industry is proven by the number of seismic crews working out of each major Company today.

Other geophysical methods have been employed in the search for oil, the torsion balance, electrical resistance, gravity studies, etc., but the seismic method is the one in most general use today.

In northern United States some geological conditions exist that affect our economy of life differently from that of the other sections of the Country. These conditions are due to the deposition of debris left by the glaciers during their sojourns and retreats from the northern section of the continent.

Continental glaciers, as we know, flowed from their centers in northern North America in all directions seeking their hydrostatic level. In their paths they picked up boulders, pebbles, sand and clay, anything that lay in their way. They scoured out valleys to a U-shaped form; wore down mountain peaks to their monadnock shape; and in general changed the existing shape of the rock surface to no little degree. In their melting back they left various deposits of gravels and clays in forms known as drumlins, eskers, kames, varved clays, glacial lake beds, and so on. These characteristics affect the gently rolling country of northern United States, but they are only surface features, and what lies beneath them may be of far different shape. The surface characteristics of the bedrock is often an important factor in the economy of a Community.

A deposit of glacial material may cover a deep and wide depression in the bedrock which acts as a splendid reservoir for a water supply. Surface waters filter through many feet of gravels and sands to be collected in such a rock basin as this. If a driller can find such a basin the Town or Community may be assured of a lasting supply of good water. However, surface forms do not necessarily tell where such a basin should be. The easiest method of finding such a basin is by seismic methods. An entire township may be surveyed in a few weeks time, and then the most promising localities, discovered by this method, studied in detail. It should be remembered, that just as in the case of petroleum exploration the seismograph does not show the existence of petroleum directly, but does demonstrate the geological conditions that should lead to a petroleum reservoir. In like manner, in searching for a water supply, the seismic method merely points out those geological conditions that should lead to water, and subsequent drilling is the proof. The seismic method has the advantage of eliminating a lot of needless drilling in the area searching for the basin formation. An ample water supply was found for the Town of Weston, Massachusetts, in this manner.

In highway construction it is frequently desired to know what lies under a hill towards which a highway is planned. Does the hill have a rock core, or is it composed entirely of gravel? How deep may the road cut be made in this hill? If there should be a rock core, it may cost ten to fifteen times more to remove the rock than if it had been gravel. Drilling will outline the rock surface, but frequently this method becomes expensive where the region is difficult to travel and the cost of bringing the drillers rig excessive. Too, a driller is frequently bid to use only flush drilling as the cost of diamond core drilling would be too much for the exploration budget. In a glaciated region this type of drilling is dangerous, as a large buried boulder might appear as bedrock to flush drilling. The seismic method is not bothered by boulders and most terrain is easily reached by the equipment, and so this method may easily show the engineer how deep his road cut may go or might even advise him to change his plans and circumvent the hill.

In road cuts a layer of clay may at times prove very costly. If this layer emerges from the cut in such a way as to drain all water in that direction, then there is danger of washouts taking place and the face of the cut would be destroyed. If the depth, dip, and direction of the drainage pattern had been known beforehand by seismic methods, then the cut could have been planned to meet these conditions.

Highway bridge foundations may be determined beforehand by this method. The cost of a bridge, or even the type of bridge may hinge on the results of such a survey.

The Commonwealth of Massachusetts' Department of Public Works has employed geological and geophysical surveys on much of its highway planning during the past few years. The United States Geological Survey and Weston College have cooperated in these problems for the Commonwealth. The former group has conducted the geological and electrical resistivity surveys, and Weston College operates the seismic surveys.

Some buildings require bedrock foundations. This is especially true in the case of large Electric Power Stations where the foundations for the turbo-generators must be secure and no danger of their settling from continuous vibration. Drilling, if used, must be made in closely spaced holes, and diamond core drills must also be employed to guarantee that bed rock has been reached. Again the matter of economy arises with this type of drilling and the cheaper seismic method could be used to great advantage. It should be remembered, especially in this problem of building foundations, that the seismic method is not a substitute for the drill, but rather they should work together. The seismologist is certain that a velocity line represents bedrock and not a boulder or some hard layer of gravels. However, his determinations of depth are not absolute, and would never be guaranteed to greater than 2% of accuracy. The driller, once he strikes bedrock, can give absolute values of depth, even with flush drilling. In glaciated regions, it remains for the seismologist to tell the driller when he has reached bedrock. Both methods should be used together, the seismic method presenting the general picture of the bedrock surface and its ap-

proximate depth, while the drilling may be concentrated in areas requiring more detail and accuracy of depth.

As one may readily see, other engineering problems fall under the scope of the seismologist. In damsites, locating the depth to which the foundation must be built; location of suitable material for the filling of earth dams; drainage conduits; strength of clays and other sediments; these are problems that fall within the scope of seismology. Tunnel planning offers problems that seismology finds easy to solve. It might be a tunnel under a river and the location of the rock under the river sediments would affect the course of the tunnel. Fortunately seismic surveys work quite as well under water as they do on dry land, although the actual work proceeds a little more slowly due to the difficulty of placing equipment. The results of these underwater surveys, however, have been very accurate.

Quarry blasting frequently produces more trouble than rock for the quarry owners. Their problem is to produce as much crushed rock as possible with a single blast to make the operations economical. If too much explosive is used, then complaints and damage claims pour in from the neighbors. Frequently these complaints are justified, but again, when the quarry owner reduces the amount of explosive, the damage claims still bother the operations. Siesmographs may be installed at various locations near the source of complaints and the amount of earth motion from the blast determined. Professor L. Don Leet of Harvard University has developed a type of seismograph especially suited for this work. It is small, light, very sensitive and with instrumental characteristics suited for this type of work. Professor Leet may set this instrument in the parlour, dining room, or wherever the damage appears, and there will record the actual motion of the house during the blasting operations from the nearby quarry. Footsteps of persons walking about the house, trucks or other traffic on a nearby street may also be recorded on the same record, and the comparison shown. Often this other traffic reveals far more damage to the house than the actual blasting from the quarry.

An explosion on the surface of the ground generates very little energy into the earth as most of it is wasted into the atmosphere. If the charge is buried, then the energy may be recorded at some distance. This is true also, if the charge is buried in water, where the hydrostatic pressure of the water tends to contain most of the generated energy. The sound waves travel through the water in all directions, and some of these strike the ocean bed, and there start a new train of waves comprising the three types used in the location of earthquakes. At Weston College, during the War, we were able to utilize this effect in locating depth bombs. An explosion of a 100 lbs. or so of high explosive presented a recording that permitted location of the explosion up to 300 miles from the station. (Fig. 3) In special tests, conducted by the Navy for our use, we were able to locate the position of the explosion within a half mile at a distance of over 200 miles from Weston College. Accordingly, every submarine explosion during the War, from northern Maine to central New Jersey was carefully logged at

Weston and the results given to the Navy to check with their own log of dropped charges. Some of the applications of this checking may not be mentioned in this paper.

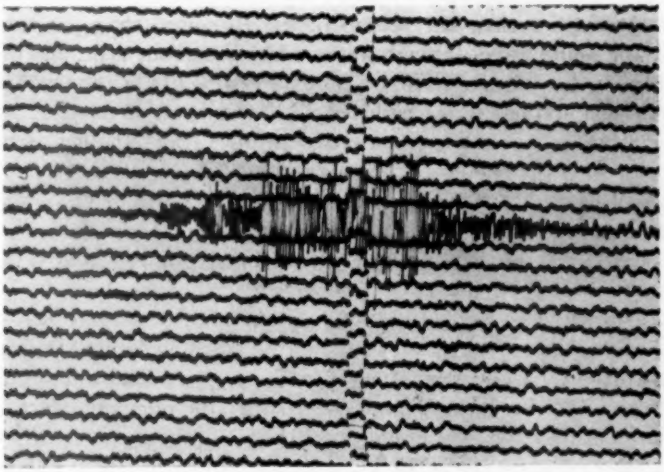


FIG. 3. Recording of 6 Depth Bombs Exploded about 90 Miles from Weston, Mass.

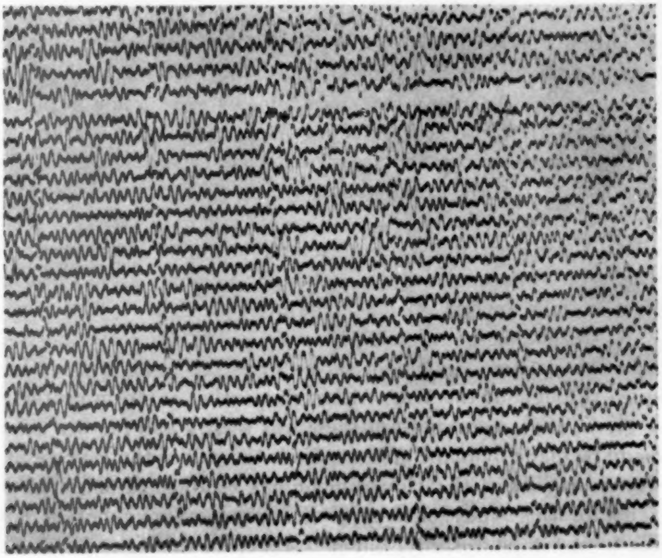


FIG. 4. Microseisms Recorded at Weston College.

We did suggest that this phenomenon might be used to signal from ship to shore during radio silence. A boat 300 miles from shore could drop a

pattern of bombs and within a few minutes that boat's position could be accurately located by seismic methods. Later in the War an adaptation of this method was developed by the Navy, but instead of using seismographs they employed sound buoys floating on water, which would record at greater distances than the seismographs. However, these instruments utilize the sound waves through water, which are of one type, and little if any idea of the distance or direction of the boat could be obtained unless several such stations were employed with accurate time control. Sound waves in water are likewise interfered with by various thermal currents, etc., that spoil the readings.

A disturbance known as a "microseism" is frequently found on seismograph records. (Fig. 4) In fact, these "microseismic storms" are at times a bother to the seismologists, as they may continue for days, and, if strong, obliterate many of the phases of an important earthquake. There have been disputes in the past as to their origin, but suffice it to state here, that most seismologists today believe they are caused by some atmospheric disturbance over an ocean. Father Gherzi, S.J., seismologist at the Jesuit Observatory, Zi-Ka-Wei, China, believed that the pumping effect of air pressure during a typhoon would cause them, and he was able to predict the passage of such a storm. He knew if such a storm was approaching the mainland from these microseisms and he could give warning to shipping near shore. Father E. Ramirez, S.J., at the Jesuit Observatory, Bogota, Colombia, S.A., made a further study of these disturbances in recent years and was able to demonstrate how the earth moved under a microseismic storm. Following the September, 1938, hurricane that effected so much damage along the New England coastline, Weston College inaugurated a study of these microseisms with a view to prediction of hurricanes from the West Indian area. It was possible to tell the inception of some storms when they were 3,000 miles from our Observatory, and as much as 24 hours before reports came from the nearest weather bureau to the storm.

To date it has been impossible to tell the distance of the storm center from the records of a single station, although a general idea of the direction has been possible. Several stations, separated by suitable distances, could locate the storm. Beginning in 1941 we were able to inform the Weather Bureau of the commencement of such storms, and this information was continued throughout the War. Although location of storm centers could not be given, the general path of these was known and further investigation could be made by plane or boat. Since the end of the War, or at least near its closing days, the Government has established seismic stations especially for this study. The type of instrument may not be entirely suitable for a complete study, but it is a step in the right direction.

In this paper, we have mentioned but a few of the By-Products of Seismology—those conducted at Weston College, and with which we are most familiar. There are many others, that space will not permit us even to mention. We do think, however, that these should prove interesting to

the physicist. A physics teacher should find plenty of examples and applications of the principles of physics in seismology, to be a help in teaching.

It has been the earnest desire of seismologists to develop a type of amateur seismology. Amateur astronomy and radio have brought great advances to those sciences, and it has been felt that seismologists could

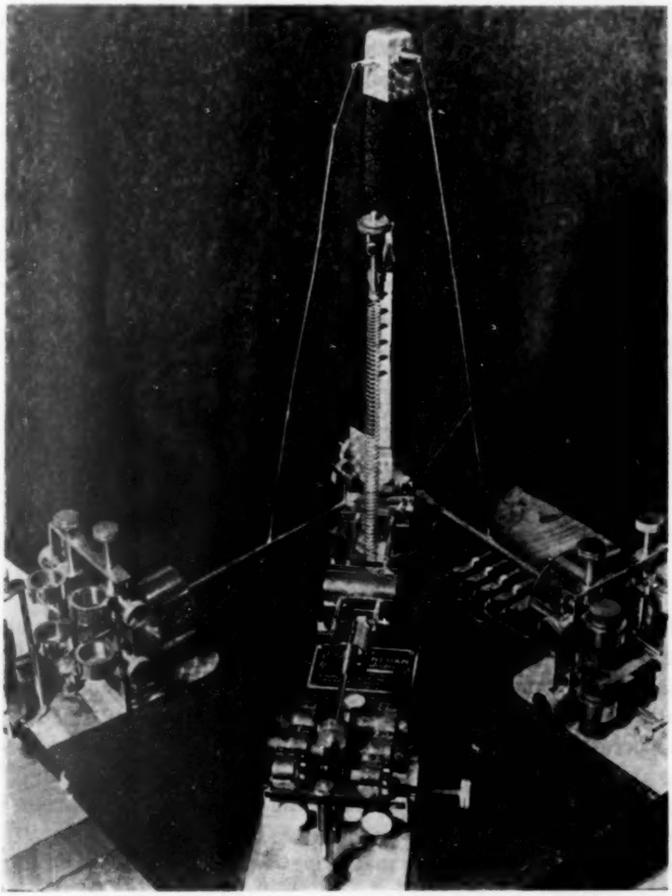


FIG. 5. The Leet-Linehan Seismograph.

learn a great deal from the amateurs in this study. To maintain interest, the amateur's instruments should record quakes frequently, at least once a week. To date, such instruments have been beyond the scope of the individual pocketbook. A High School or even most College Departments have found it difficult to include such equipment in their budgets.

A new instrument known as the "Leet-Linehan Seismograph," which will be in production near the end of 1946, is one we believe will meet these

requirements. (Fig. 5) It is extremely sensitive; the instrumental characteristics may be changed to arrange study for various types of disturbances, whether distant or near quakes, blasts, or hurricanes. The operation will be inexpensive as no photographic paper is used for recording, and the instrument need be tended but once a week, thus eliminating the daily attendance as practiced in most Observatories.

It is doubtful whether every boy or girl could buy such an instrument for a hobby, but it will be within the High School budget, Museum, Library or some Public Buildings. Due to its high sensitivity and magnification, and low cost of purchase and operation, we hope that this will be the means for arousing the interest of the amateur. Mr. R. L. Arringdale of the Diamond Instrument Company, Wakefield, Massachusetts, is the designer of this instrument and he has incorporated many ideas that are new to seismic recording. Several electronic devices developed during the past few years are used in this seismograph and a sensitivity is expected that will be comparable to that employed in the better Observatories. Although Mr. Arringdale has not designed this seismograph with the "professed" seismologist in mind, it is felt it will be a necessary adjunct to every first class Observatory.

CORRELATION BETWEEN PHYSICS AND MATHEMATICS GRADES

ALBERT THORNDIKE
Milton Academy

The teacher of physics in a college preparatory school is very apt, as the end of a school year approaches, to have students ask him about a physics course. The prospective physics student not only wants to find out about the content of the course but is usually curious about the prospects of his success or failure in keeping up with the class. Not only has he something at stake, but also we, on the other side of the lecture table, have much to gain by giving good advice on the student's choice of courses for the ensuing year.

Some Science Departments may have fairly definite regulations as to the qualifications of a student before he is allowed to enter the regular college preparatory physics course. However most do not, relying on good judgment based on good advice to exclude students who would tend to be a drag on the class as a whole. All those with whom I have discussed the question have had the feeling that the student's past record in mathematics is a clue to his probable standing in college preparatory physics, probably the best clue apart from a genuine interest in the subject-matter itself. Never myself having seen any figures to back up this general opinion, I made a short statistical study. Members of the Faculties of other schools perhaps will be as interested in the results as we were at Milton Academy.

From the school files a choice was made of recent students whose records could be termed a representative sample. Scatter diagrams were then prepared to show distribution of grades. Data were obtained on foreign language ability as well as on mathematical ability because of the danger in drawing any conclusion from the latter alone. It was felt that the former would provide assurance that the sample did not contain merely those students who would do well in (or badly in) whatever courses they might take. The following figures show not the original points as plotted on a scatter diagram, but smoothed curves of grades as averaged from both axes of the distribution.

The first figure shows the physics-foreign language comparison: To

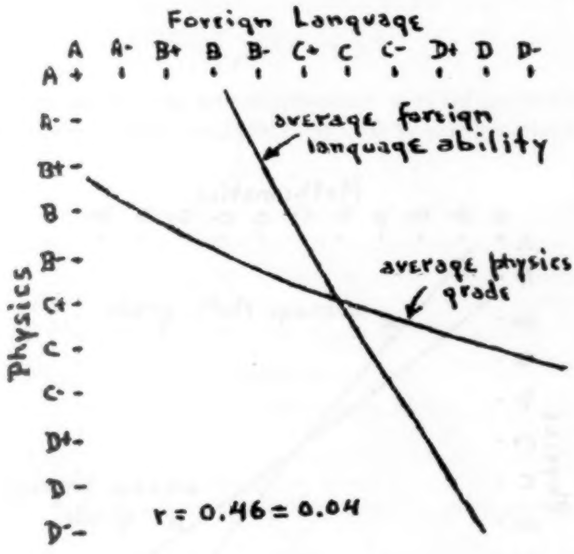


FIG. 1

illustrate this type of plot, one could read a point on the "average physics grade" curve as "for those who had an A-ability in foreign languages, the average grade in physics was B." If all students received the same grade in one field as in the other (a perfect correlation), the two curves would, of course, coincide and become a straight line at 45° to the axes; as the two become less related, the lines separate. Should one average line be horizontal and the other vertical, it would indicate that the two quantities had no effect on each other; for example, if that were the case in Figure 1, it would show that no matter what ability students might demonstrate in physics, their average foreign language ability would be the same. Should the two lines cross so that the obtuse angle were toward the intersection of axes, it would indicate a negative correlation. (It might be noted here that in both diagrams presented the median grades might just as well have been used as the average grades.)

In plotting Figure 1 the foreign language ability measurement was taken as being the average of year grades in modern foreign languages obtained by a student in four years, with a correction in a downward direction for repetition of a course or for giving up one language and taking up another (as this usually means that the advanced courses are over-difficult for the student, and he has elected to study languages only at the elementary level). The correlation coefficient indicated in the lower left corner of each figure was computed by the formula:

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$$

the Probable Error by:

$$\text{P.E.} = \pm 0.67\,\frac{(1-r^2)}{\sqrt{n}}\,.$$

The correlation between mathematics and physics can be seen to be much closer by a glance at the curves of Figure 2 or by comparison of the

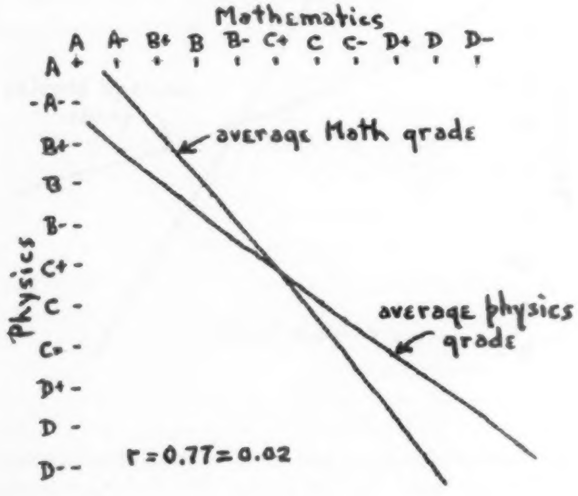


FIG. 2

correlation coefficient of 0.77 with the 0.46 coefficient of the language-physics study. The grades used for mathematical ability are again averages, corrected for any cases of repetition, but in this case averages only of three year-grades instead of four. This was done because the purpose of the study was to determine the value of a student's record in mathematics previous to the undertaking of physics as a basis for making a forecast.

The question as to whether a student's grades in geometry would be more indicative than his average ability in all phases of algebra and geometry was also investigated. It was thought that perhaps the deductive

reasoning, necessary in this branch of the field, which is so useful in physics would show up. The correlation was not quite as good as for the general mathematics average. It would be interesting to discover whether the "original proposition" might not be a good measure.

The danger, of course, in any statistical figures is that they can easily be misused. We cannot conclude from the high mathematics-physics correlation, for example, that a student whose mathematical ability is low will certainly be a detriment to our next year's physics course. Nor should the brilliant mathematics student necessarily be encouraged to study in the field of physics. All that I feel that has been accomplished by this little study is that we now have instead of a "hunch" a "good bet" when we ask a prospective physics student about how he has been doing in mathematics.

DYNAMIC ILLUSTRATION OF THE GAS LAWS BY SHADOW PROJECTION

BERNARD A. FIEKERS, S.J.

The speaker gave a very interesting demonstration of the gas laws using a kinetic illustrator by which the motion of small steel spheres is projected on the screen in such a way as to illustrate these laws. The apparatus is pictured and the method described in articles previously published, so it was thought best merely to refer the reader to these sources.

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APPLIED SPECTROSCOPY IN THE LIBERAL ARTS COLLEGE

R. C. GUNTER, JR.
Assistant Professor of Physics, Clark University
Assistant Director, Optical Research Laboratory, Boston University

I. INTRODUCTION

A. Purpose of Talk

My subject is "Applied Spectroscopy in the Liberal Arts College." In this talk I would like to discuss with you some of the problems involved in

setting up a course in undergraduate spectroscopy that features laboratory as well as lecture work. In doing so, I would like to also call your attention to the versatility of spectroscopy as a teaching vehicle, not only for the purpose of teaching spectroscopy but also for the purpose of teaching certain other phases of optics and electricity.

B. Spectroscopy Laboratory at Clark

When I came to Clark University, Dr. P. M. Roope, Chairman of the Physics Department agreed to establish an undergraduate spectrographic laboratory. Although the laboratory has not expanded as rapidly as desired, because of the war, and my leave of absence to the Radar School at M.I.T., still the results of the laboratory to date, have been on the whole satisfactory. Several graduate theses have been done on the present spectrographic equipment under the joint sponsorship of the Chemistry and Physics Departments. A twenty-one foot concave grating spectrograph of the Eagle type is under construction at present.

II. BRIEF REVIEW

Although a good many of you are certainly familiar with applied spectroscopy, I believe it will be advantageous at this point to delve briefly into its pertinent background to refresh our memories before proceeding further.

A. Types of Spectra

1. In general there are two broad types of spectra, emission and absorption. The difference between these two may best be shown by resorting to one of Bohr's Postulates.

$$\nu = \frac{W_2 - W_1}{h}.$$

If $W_2 > W_1$, γ is frequency of emitted radiation
If $W_2 < W_1$, γ is frequency of absorbed radiation

2. A further distinction is usually made between line, band, and continuous spectra. *Line* spectra occurs when the emitted or absorbed radiation shows up as a series of discrete radiations. For certain atoms and molecules bands appear such that the lines get closer and closer together, and approach a head or series limit. The continuous spectrum is simply one in which all wavelengths are present.

B. Spectrographs

As you will find in any college elementary physics book, the principal devices for analyzing spectra are the simple prism, and the ruled grating. There are several types of prism spectrographs and also several types of grating spectrographs.

1. Prism

The simplest type of prism spectrograph is the straight line prism type

which is shown schematically in Figure 1. The action of this prism spectrograph is quite simple. Light is focused by means of the focusing lens (L_1) upon the slite (S) of the spectroscope in such a manner that an inverted image of the electrodes appears just off the limits of the face of the collimating lens (L_2). The purpose of the collimating lens is to render all light that strikes the prism face parallel. The alignment of the spectrograph will not be gone into at this point but if anyone has questions on the subject, I will be very glad to discuss it in the question session. After passing through the prism, the various wave lengths are bent in accordance with their various indices of refractions; pass through a focusing lens (L_3) and appears as images of the slit on a photographic plate. Usually the slit is a narrow rectangular opening hence the images of the slit are referred to as "lines." Incidentally, there are several types of photographic plates used in spectrographic work. Some sensitive for the infra-red, some for

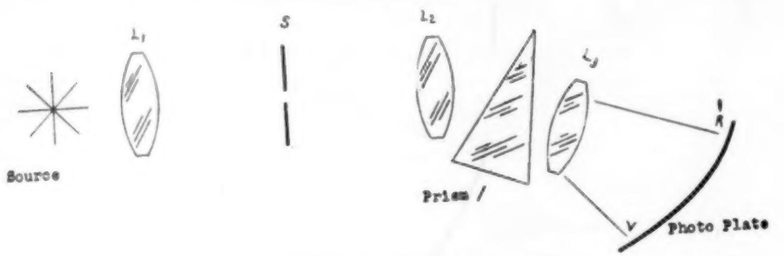


FIG. 1. A Simple Type Prism Spectrograph

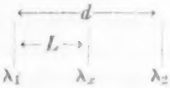
the middle region, that is between 4,000 and 6,000 Angstroms, and some for the ultraviolet region below about 4,000 Angstroms. In general, quartz lenses and prisms are employed inasmuch as pyrex absorbs all radiation below approximately 3,000 Angstroms. With an air spectrograph one can not go much below 2,000 Å as the air begins to absorb radiation below approximately 2,200 Å.

2. Grating

Let us look at a simple grating spectrograph. Light from the electrodes is focused on the slit and thence onto a concave grating which selectively diffracts the various wave lengths to photographic plate as we see in Figure 2. We thus obtain either method, a photographic plate with various lines on it indicative of the wave lengths of the radiation that comes from the arc or spark electrodes.

C. Measurement

Now, how are we going to determine the wave length of these lines? There are several methods available. First of all we can directly compare them with spectra whose wave lengths are known. Secondly, find wave lengths between known wave lengths, interpolation may be used for example:



$$\lambda_x=\lambda_1+\left(\frac{\lambda_2-\lambda_1}{d}\right)L, \quad \text{if} \quad \lambda_2>\lambda_1$$

If d is large, this linear interpolation may be inaccurate and we must resort to the dispersion curve for the spectrograph.

We define the term dispersion, from a strictly optical point of view as "the deviation in angle per unit wave-length," or in mathematical terms, $d\theta/d\lambda$. Practically, however, most spectrographic measurements are made on a somewhat different definition of dispersion. Here we define dispersion as the number of Angstroms per mm on the photographic plate, $d\lambda/dl$.

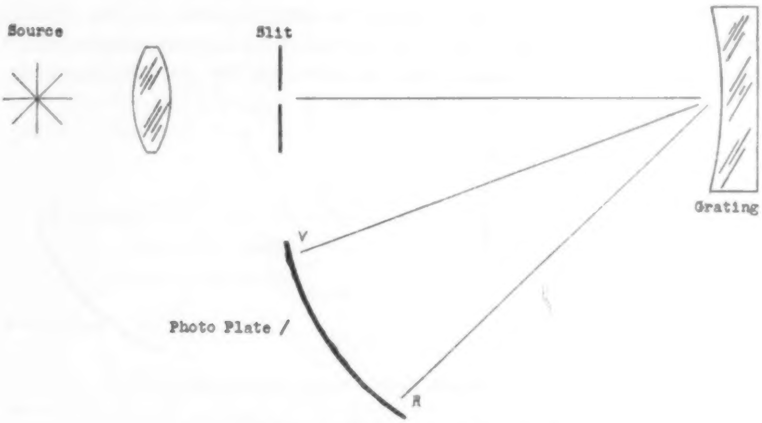


FIG. 2. A Simple Grating Spectograph

The reason for the change in definition of the term dispersion is that it is inconvenient with ordinary equipment to measure the optical dispersion, whereas the spectrographic dispersion can be measured easily on the photographic plate. This spectrographic dispersion is clearly a function of the optical dispersion as we will show by the following equations:

$$l=f\theta \tag{1}$$

$$\frac{dl}{d\lambda}=f\frac{d\theta}{d\lambda} \tag{2}$$

$$\therefore \frac{d\lambda}{dl}=\frac{1}{f\dfrac{d\theta}{d\lambda}}. \tag{3}$$

where l = separation between two lines $d\lambda$ apart, and f = focal length of focusing lens or grating

Optical dispersion $=d\theta/d\lambda$ and spectrographic dispersion $=d\lambda/dl$, hence high dispersion in the optical system means a low number of Angstrom/mm. The spectrographic dispersion will hereafter be implied whenever the term dispersion is used. A quartz prism spectrograph will, in general, have a dis-

persion curve as shown in Figure 3 whereas a grating spectrograph will usually have the following dispersion curve: (Fig. 4) You will note that the grating spectrograph produces a very much more linear dispersion curve. This advantage of the grating spectrograph as well as the fact that the incident light does not have to go through it with consequent absorption, has, in later years, been ruling out the use of the prism to a greater and greater extent. This is particularly true now that ruled gratings can be

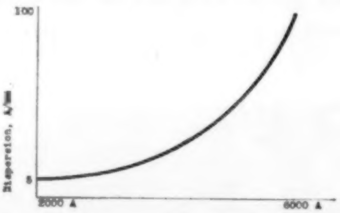


FIG. 3. A Prism Dispersion Curve

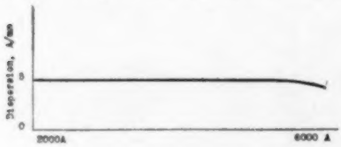


FIG. 4. A Grating Dispersion Curve

obtained for approximately the same cost as prisms. I believe a rough cost figure, applicable to both prisms and gratings is about $100 per sq. in. of surface (surface of one face of the prism). Replica gratings made of cellophane by flowing it over a ruled grating and then removing and mounting it are highly satisfactory for ordinary laboratory work. Their cost is but a fraction of the cost of a ruled grating; replica gratings costing approximately $350. Complete commercial automatic type ruled grating spectrographs cost approximately $5,000 whereas the replica type cost only about $350.

III. QUALITATIVE ANALYSIS

Now, having the dispersion curve for a given spectrograph, and at least one known wave length, it is possible as we have shown, to measure from this wave length and determine the wave length of all other unknown lines. Using the theory that a given line is characteristic of one and only one element, it is then possible to measure various lines on the plate and ascertain the elements present in the electrodes. There are some attendant difficulties to this method, principally that of time consumption, consequently we generally do not often use this method for qualitative analysis.

As a typical example, let us make a qualitative analysis of the ordinary dentist's silver amalgam with which too many of us undoubtedly have had painful experience. Here we will take the dentist's amalgam, form it into

a powder and place it in the lower electrode of a carbon arc. We will then apply approximately 300V DC to the electrodes, limit the current by a series resistor to approximately 3 amps and take a spectrogram of the resultant arc. Experience tells us that we might expect to find metals such as copper, tin, zinc, and so forth in this amalgam. Let us check the amalgam for the presence of these metals. To do this we shall take photographs of the spectra of amalgam, Zn, amalgam Cu, amalgam, and Sn in order and arranged so that they are in juxtaposition. We now develop the photographic plate, and analyze it. Figure 5 shows a part of the resultant spectrogram.

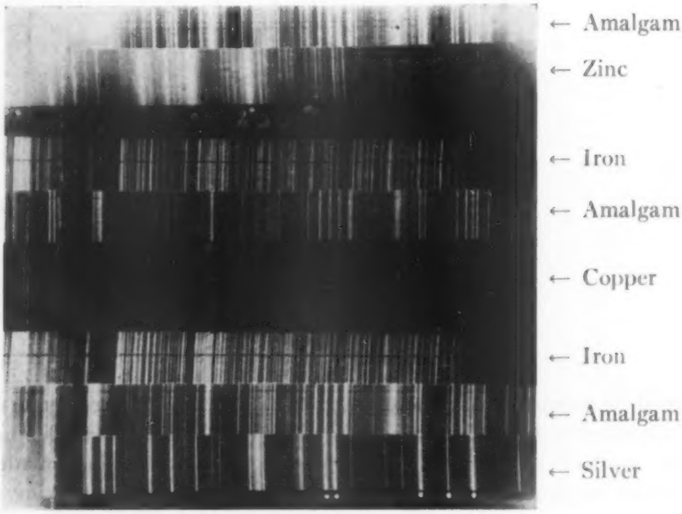


FIG. 5. Spectrogram of Dentist's Amalgam Showing Presence of Silver, Copper, Zinc, and Iron

I have dotted some of the more critical lines of copper, zinc, and tin. If these lines are present in the amalgam, then quite possibly the element is in the amalgam also. Should one line alone of an element be found common to both spectra, it is not accepted as conclusive proof of the elements presence, so we usually use three lines. In Harrison's *Wave-length Tables*, we find the lines which are most persistent, that is which are present longest as the concentration is decreased consequently are most typical of a given element. (It is interesting to note here that copper as low as one part per million may be readily ascertained in an ordinary laboratory. In fact I gave just this very problem to a student for his final laboratory examination. He was analyzing well water, for copper absorbed from pipes and storage tanks.) I think it is clear by inspection of this spectrogram that we have the Cu and Sn but little or no Zn in the dentist amalgam. You will note that there is a strong line between the 3247.6 and the 3274.0 copper

lines in the amalgam. This line does not appear in any of the known spectra but may be determined by extrapolation by the method previously discussed. The distance between the Cu lines on the screen is 127 mm, hence the approximate dispersion is:

$$\frac{3274.0-3247.6}{127}$$

and the wavelength of this unknown line is:

$$3247.0+\frac{3274.0-3247.6}{127}\times 65 = 3261\text{Å}.$$

Reference to tables shows this to be a strong Cadmium line. The presence of cadmium is, therefore, suspected and confirmation may be affected by looking for other cadmium lines. If a complete analysis were required, we would be faced with the problem of either measuring all of the lines or using what is called RU powder (RU is an abbreviation for the French expression "Raies Ultimes"), made by Adam Hilger. This powder contains a small amount, in controlled concentration, of practically all the elements. Calibration plates come with this powder so that it is a simple matter to use the RU powder as a comparison with the unknown spectra and to thereby identify a very large number of elements rapidly. Qualitative spectro-chemical analysis has progressed to such a point where some chemists, now actively advocate no longer teaching chemical inorganic qualitative analysis. I personally do not hold this point of view inasmuch as in order to perform many spectrographic analyses, it is necessary to have a fairly good chemical background. In general, I require at least one course in college chemistry before a student is allowed to take my applied spectroscopy courses.

IV. QUANTITATIVE ANALYSIS

Let us now have a look at the principles employed in spectral quantitative analysis. The fundamental principle is that the intensity of radiation, for a given element, from the arc or the spark is a function of the concentration of the element in the electrodes. I think it is fairly clear that this intensity is also a function of the temperature of the arc, the length of the exposure, photographic development conditions, and response of photographic plate to variation in exposure and wave length.

By standardizing these conditions it is possible to reduce the effect of these variables but the response of the photographic plate must be quantitatively taken into consideration. To do this we plot the curve shown in Figure 6. It is not necessary, generally speaking, to consider quantitatively the variation of "d" with "λ" inasmuch as the spread in λ is usually sufficiently small to assume "d" is constant. Further, by using what is termed "an internal standard" it is possible to make our observations and calculations to a very large extent independent of arc or spark fluctuations, or varying conditions of photographic exposure and development.

Before we go into the method of the internal standard, let us make a simple "paper" quantitative experiment. Suppose we have a sample of aluminum that contains one per cent copper. We would expect to get the usual aluminum spectrum with its characteristic lines and in addition, the copper lines. The question now arises, which lines shall we use for our analysis? Unfortunately the lines which are most suited to qualitative analysis are not necessarily most suited to quantitative analysis. The reason for this is that in many cases the lines which are most suited to

d = density of image
i = intensity of incident radiation

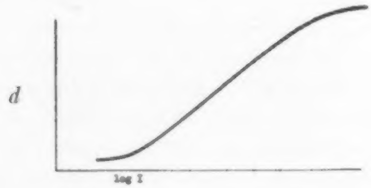


FIG. 6. Curve Showing Variation of Density of Image with Logarithm of Intensity of Incident Radiation

qualitative analysis are those which show least variation with concentration, whereas for quantitative analysis we desire lines which are very sensitive to concentration. If we go back to our case of aluminum and its alloying element copper and add one per cent, then two per cent of copper, then three per cent copper, then four per cent copper, etc., it will be clear to us that we will get an increase in the intensity of the copper line selected as the concentration increases. Let us for a moment pre-suppose that we can standardize all photographic and spectrographic elements and simply concentrate on the variation of intensity. That is, we will assume that the variation of intensity of the selected copper line is a function solely of the variation in concentration.

From the data collected, we may now plot a curve of density on the photographic plate against concentration. The concentration of copper in a similar aluminum matrix may now be determined. We expose it and measure the intensity of the selected copper line. Then by referring to our chart we can determine the concentration of the copper.

As I have mentioned before, the arc and spark fluctuate considerably, developing and exposing conditions from a photographic point of view cannot be maintained exactly constant, hence our assumption that the intensity is a function of concentration alone is not entirely justified. To compensate for this, we pick out a line in the main spectrum of aluminum, close to the selected copper line and use it as an internal standard. That is instead of plotting the density of the selected copper line alone, we will plot the density of the copper line, divided by the density of the selected

internal standard. This ratio will be approximately the same for any developing or exposing condition, hence the name internal standard. It is desirous of course that the line chosen in the main body element be insensitive to changes in concentration, but be very sensitive to changes in arc and spark conditions. Further, the two lines must be close together to obviate necessity for a $d-\lambda$ calibration of the plate. In general, it is not difficult to find a line suitable for use as an internal standard. The actual method involved in determining the concentration by the method of internal standards is similar to that which we have already mentioned

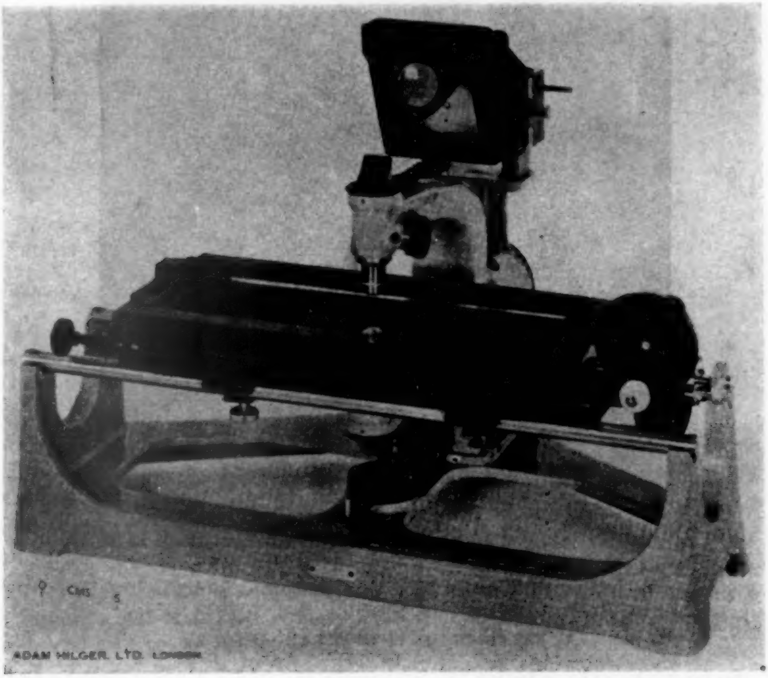


FIG. 7. The Log Sector Method for Quantitative Analysis

and differs only in that we plot da/ds against log Ca (da = density of alloying element; ds = density of internal standard and Ca = concentration of alloying element). Another method available for quantitative analysis is the log sector method. No equipment additional to that necessary for ordinary qualitative analysis is needed but is not very precise. The method employs a disc whose periphery is cut into the shape of a logarithmic spiral and spun rapidly in front of the slit of a spectrograph. (Fig. 7) It is easy to see that the length of line on the plate will be a function of the logarithmic intensity of the line, hence we follow our previous internal standard procedures but compare lengths instead of densities. Figure 8

shows a spectrogram made with such a disc. (Photo of Wood's Metal; white dots indicate ends of lines.)

FIG. 8. Wood's Metal Logarithmic Sector

V. ESTABLISHMENT OF A LABORATORY

So far we have been laying the background for an understanding of what must be performed in the lecture. In order to set up a spectrographic laboratory in a Liberal Arts College where funds for Physics are many times limited, we must economize at every point and yet not cut short our standards. Perhaps the best way to outline some of the problems involved in setting up a spectrographic laboratory is to go through some of the problems that we faced at Clark in setting up our laboratory. First of all we had to get a spectrograph. We were actually rather fortunate in this quest and found that the college possessed one that was not in use at the moment—a joint possession of the Physics and Chemistry Departments. The construction of an arc and spark source with stand was done from miscellaneous materials lying around the laboratory. The final form of our DC arc source is as follows: (Figure 9). The final form of our spark source is

as shown below (Fig. 10). Incidentally it is advisable to have both arc and spark sources inasmuch as some metals are more sensitive to spark than to arc and vice-versa. Both AC and DC arcs are employed. We use principally the DC arc as it is safer for student use than the AC arc although it does give less reproducible results.

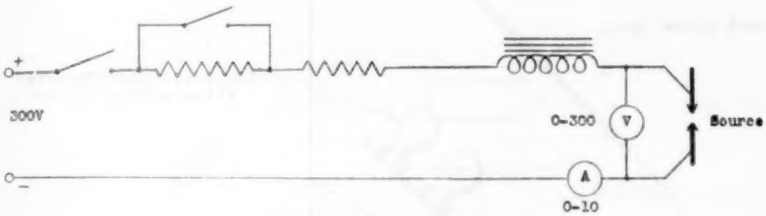


FIG. 9. A DC Arc Source

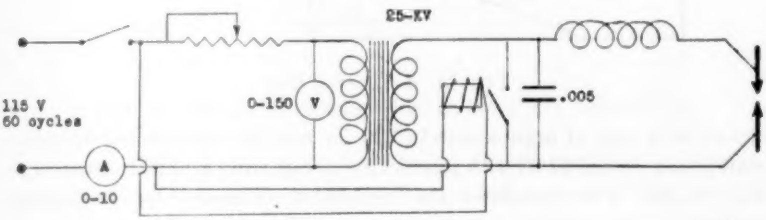


FIG. 10. A Spark Source

Some sort of an electrode holder must be fashioned. It can be done out of ordinary ring stands and supporting clamps but I think that you will find that it is advantageous and time saving in the end, to devise a stand whereby the electrodes can be positioned while an exposure is being made and positioned not only as far as separation, but also the arc or spark moved up and down in a vertical plane or moved backwards and forwards along some sort of an optical bench. We did not have the necessary optical bench so we used an old lathe bed.

Next comes the problem of measuring the distance between spectrum lines. This is used for calculating dispersion curves and occasionally for qualitative analysis. We happened to have a measuring instrument, one of the original Michelson comparators, which we redesigned for our purposes. Actually this device is not absolutely necessary inasmuch as enlargement by an ordinary camera enlarger will yield line separations such that they may be measured for all practical purposes, by means of an ordinary meter stick. If an enlarger is not available, it is possible to use the very inexpensive Bausch and Lomb measuring eye-piece such as I have here. In actual practice relatively little line measurement is done as practically all of the qualitative analysis is performed by comparison methods.

The next item to be constructed or purchased are viewing boxes. Viewing boxes are devices designed to furnish a uniformly illuminated back-

ground against which the spectrogram may be viewed. One of those constructed at Clark is shown in Figure 11. This viewing box may be pur-

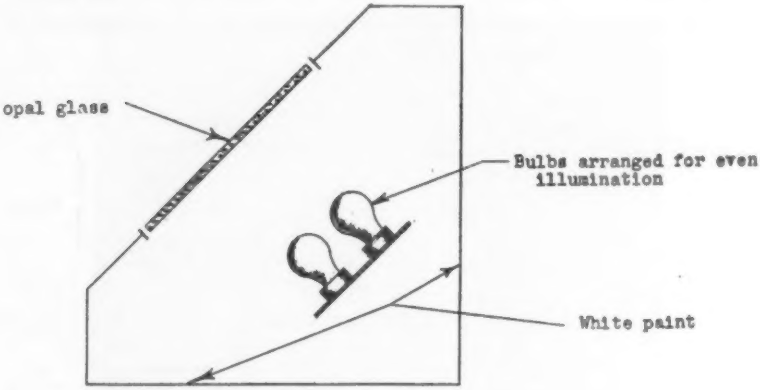


FIG. 11. A Viewing Box

chased at a cost of approximately $20, or may be constructed approximately at a cost of $2.00 with practically no ingenuity and fully as acceptable results. This completes the equipment necessary for qualitative analysis.

For quantitative analysis, some sort of a densitometer, a device designed to measure the relative density of the lines on the photographic plate, must be constructed or purchased. Figure 12 shows an excellent type manufactured by Adam Hilger. A light source below the plate shines light up

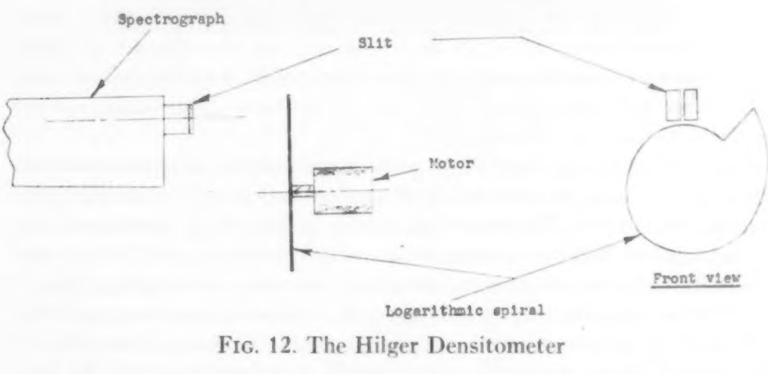


FIG. 12. The Hilger Densitometer

through the spectrogram and thence to a slit in front of a photo-voltaic cell. The output of the cell is fed to a galvanometer which can easily be calibrated in densities. The simplest possible type is preferred inasmuch as it will teach as much if not more—than the complicated automatic recording types. Here again at Clark we were faced with the problem of shall we

buy one and spend somewhere from $1,200 to $2,000 or shall we try to fashion one ourselves? The decision that was forced on us is obvious to most of you. We happened to have a microscope attachment in the laboratory that had been used in connection with some other investigations. It was constructed as shown in Figure 13. The attachment was

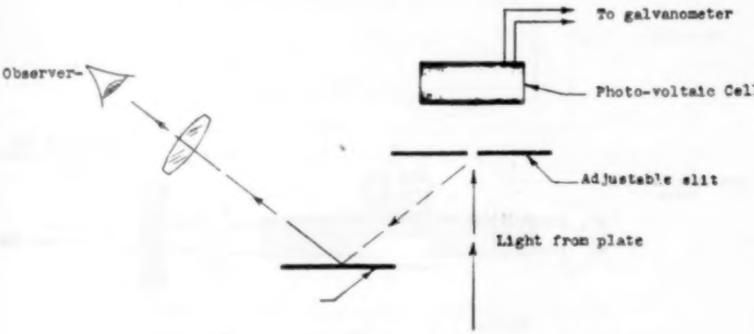


FIG. 13. The Densitometer Used at the Clark Laboratory

manufactured by Reichertz in Austria and distributed by an optical importing house in New York City. I do not know whether they are still available, but if you can get one, you will find it makes a very satisfactory and inexpensive densitometer in connection with a galvanometer and a microscope.

This particular eye-piece allows the observer to look directly at the line under investigation, as well as allow the light that is passing through the plate to go up through the slit and onto the photo-electric cell. The advantage of being able to look directly at the line while it is being measured is very great inasmuch as otherwise it is practically impossible to tell just which line is being measured. The output of this photo-cell is sent to a galvanometer that has a fairly high sensitivity. Actually this galvanometer is not as suitable as it might have been inasmuch as it has a relatively long response time, and when you have many students desiring to use one densitometer, time is very definitely a factor. At any rate, the light from the galvanometer bulb is reflected off the galvanometer mirror as a thin line and appears just above the densitometer on a translucent scale. Since the motion of the galvanometer mirror is a function of the photo-cell current, the position of the bright line of light on the translucent scale is a function of the intensity or the light that fell upon the photographic plate. It is not necessary to measure the intensity of the light in candle power as relative intensities alone are used. Thus we can plot our calibration curves for the photographic plate simply in terms of galvanometer divisions. There are several mechanical problems as well as optical problems involved in constructing a densitometer. First of all it is necessary to have a staging upon which we can rest the photographic plate.

This staging must be capable of wide latitude of movement, as well as extremely fine movement once we are on the lines to be measured. To get the latitude of movement necessary to cover the entire photographic plate,

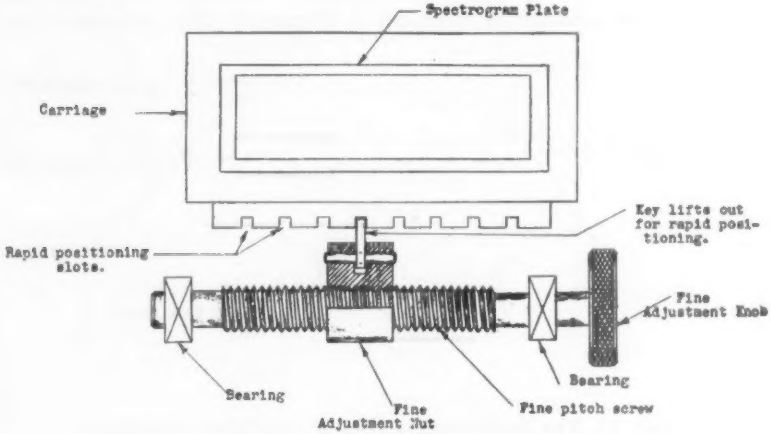


FIG. 14. The Staging for the Photographic Plate

I rigged up a system as follows: (Fig. 14) Being somewhat of an amateur machinist, I cut the screw myself that was used to drive the plate over the narrow region occupied by the spectrum line. In order to reduce blacklash, a spring and suspended weight combination was used as shown: (Fig. 15)

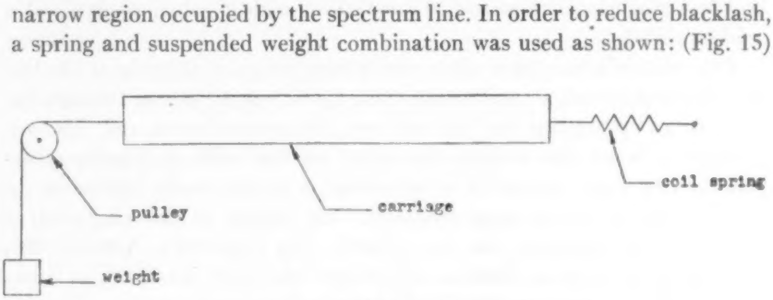


FIG. 15. Scheme for Reducing Backlash

For an optical bench I employed another lathe bed, somewhat smaller than that used for the optical bench. You undoubtedly could rig one up with parallel rods or the equivalent. Cenco, I believe, has a good optical bench for this purpose. However, you certainly can construct one considerably cheaper than you can buy one, and to a large extent do just as good a job.

This just about completes the optical equipment necessary to perform spectrographic qualitative and quantitative analysis. There are certain other accessories which must be present and to which we must give some thought. First of all it is advisable to have a moderately well stocked

supply of chemical reagents, as pure as possible. Secondly, an adequate dark room must be prepared and the closer to the spectroscopy laboratory the better. This dark room should be of the maze type, i.e. have no doors. Figure 16 shows a sketch of one in use at Clark.

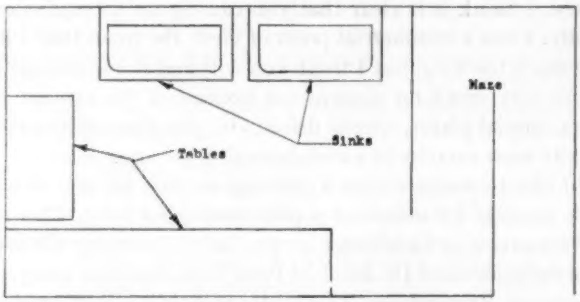


FIG. 16. Plan of the Clark Dark Room

Inasmuch as you will find that a course in spectro-chemical analysis is quite popular with the students, physicists, chemists, biologists, alike; classes are apt to be large and it is best to develop certain relatively high speed methods of processing the photographic plate. We have used a pan type of developer made in the laboratory for both developing and fixing

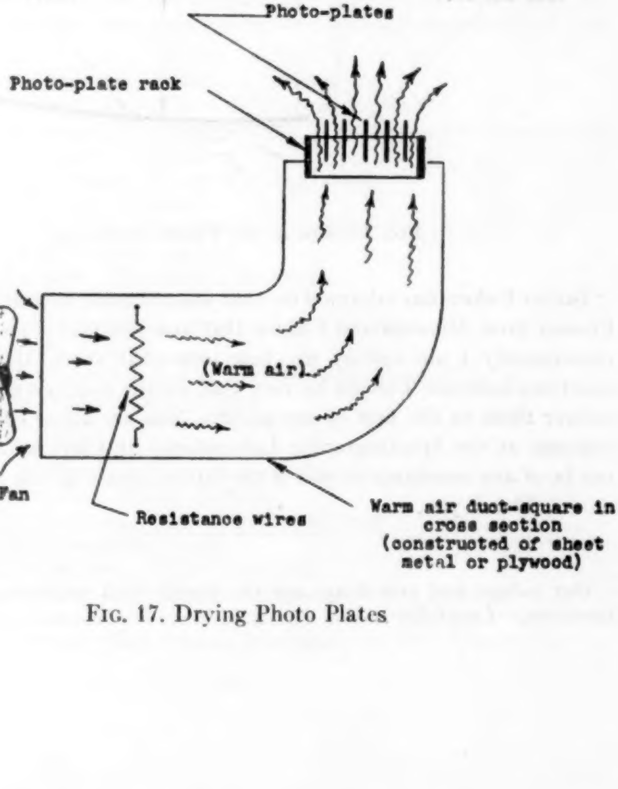


FIG. 17. Drying Photo Plates

and have found that the use of Aerosal has decreased our developing time and fixing time by approximately 30 percent. I believe you will find that it is possible to get your developing time down to about two minutes, the fixing time, washing and drying, down to about five minutes each. To dry we used forded warm air. Figure 17 is a sketch which one of my students constructed. I think it is clear that you can rig up an equivalent device fairly easily. From a commercial point of view, the times that I have indicated are much too long, but I think you will find it impractical to reduce these times very much for student use because of the expense of special developers, special plates, special driers, etc. plus the additional care that the students must exercise to avoid damaging the emulsion.

I would like to indicate here a growing method for determining these intensities directly by means of a photomultiplier tube. This method is under investigation in Cambridge by the Baird Associates for use in commercial installations and Dr. Rank of Penn State has been using it for some time to measure Raman lines. This is also a project under development at the Clark University Spectrographic Laboratory. One method of using the photo-multiplier is briefly shown in the Figure 18.

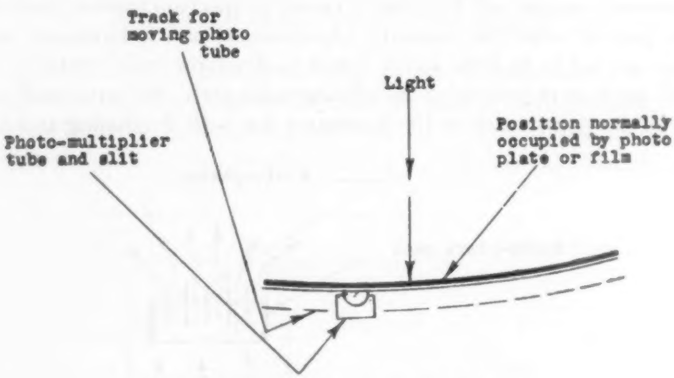


FIG. 18. Use of the Photo-Multiplier

Father Fiekers has informed me that you are going to visit the Worcester Pressed Steel Museum and I know that you will find it most interesting, consequently I am cutting my talk somewhat short. If you have any questions however, I would be very glad for the next ten minutes or so to answer them to the best of my ability. You are all of course, cordially welcome at the Spectrographic Laboratories at Clark at any time. If I can be of any assistance to you in the future, please do not hesitate to call on me. Thank you.

Our todays and yesterdays are the blocks with which we build our tomorrows.—*Longfellow*.

EAT TURKEY BUT ATTEND THE THANKSGIVING CASMT CONVENTION

ARTHUR O. BAKER, *President*

For approximately the past fifty years members of the Central Association of Science and Mathematics Teachers have been meeting at Thanksgiving time. Hence, PLAN NOW to eat turkey as usual but to attend also the 1946 convention. This year the convention will emphasize the implications of "New Power, Products, and Personnel" for revolutionized post-war living. Along with eating turkey, teachers in the mid-western United States will want to enjoy the:

1. GENERAL MEETINGS
   Friday, November 29, 9:30 A.M.–11:45 A.M.
   Saturday, November 30, 9:00–10:00 A.M.
2. EXHIBITS
   Friday, November 29, 8:30 A.M.–9:00 P.M.
   Saturday, November 30, 8:15 A.M.–12:00 noon
3. SPECIAL CONVENTION LUNCHEON
   Friday, November 29, 12:00 noon
4. SECTION MEETINGS
   Friday, November 29, 2:15 P.M.–4:30 P.M.
5. ANNUAL BANQUET
   Friday, November 29, 7:00 P.M.
6. GROUP MEETINGS
   Saturday, November 30 ,10:00 A.M.–11:30 A.M.
7. FREE LUNCHEON AND SPECIAL TRIP
   Saturday, November 30, 12:15 P.M.–5:00 P.M.

Much planning has gone into preparations for the above meetings. Locally this planning has been handled by the following chairmen and committees:

Emil L. Massey, Chairman, ADVISORY COMMITTEE
Division of Instruction, Board of Education, Detroit
Allen F. Meyer, General Chairman, LOCAL ARRANGEMENTS COMMITTEES
Mackenzie High School, Detroit
Dorothy Tryon, Chairman, BANQUET COMMITTEE
Redford High School, Detroit
Clarence J. Leonard, Chairman, CONDUCT OF MEETINGS COMMITTEE
Southeastern High School, Detroit
RAY AGREN, Chairman, EXHIBITS COMMITTEE
Southfield Trade School, Detroit
Elsie Townsend, Chairman, HOSPITALITY COMMITTEE
Wayne University, Detroit
FRANKLIN FREY, Chairman, LOCAL MEMBERSHIP COMMITTEE
Cass Technical High School, Detroit
Lydia Elzey, Chairman, LUNCHEON COMMITTEE
Mackenzie High School, Detroit
Duncan Pirie, Chairman, PUBLICITY COMMITTEE
Jefferson Intermediate School, Detroit
Phebe Mitchell, Chairman, STATISTICS COMMITTEE
Dearborn High School, Dearborn
Melvin Yahnke, Chairman, TRIP COMMITTEE
The Edison Institute High School, Dearborn
Max Irland, Co-Chairman, TRIP COMMITTEE
The Edison Institute High School, Dearborn

Hence, a real treat would seem to be approaching for science and mathematics teachers in mid-western United States.

This convention will take place at the Book-Cadillac Hotel in Detroit on November 28, 29, and 30, 1946. Secure your room reservation NOW by writing directly to: Mr. C. B. Loftis, Front Office Manager, Book-Cadillac Hotel, Detroit 31, Michigan.

By the time of this convention the atomic bomb tests on Bikini Atoll will have taken place. Much will have been learned about NEW POWER and how it can be unleashed! The story of Bikini Atoll, atomic energy, and other sources of new power such as that obtained through electronic, turbine, rocket, and jet propulsion principles will be presented during this coming convention. Since it is ordinarily only possible to change about forty per cent of the energy of coal into electric energy, it would seem highly possible that when NEW POWER sources have been tapped it might bring us to the threshold of a great period of industrial expansion, and hence, to revolutionized living. Teachers of science and mathematics will want to hear these predictions for the future.

Along with new power releases and the continuing of scientific research will come a flood of NEW PRODUCTS, materials, and services. Already many new products and gadgets, some very practical and worthwhile, others of doubtful value, and many with exorbitant prices, have appeared. Teachers of science and mathematics will want to know more about what can be done in the classroom to make boys and girls wiser consumers.

The problem of PERSONNEL, too, will engage the attention of conventioneers at the Thanksgiving sessions. Teachers will want to learn more about ways of encouraging pupils of recognized ability to plan for careers in the fields of mathematics and science. It is estimated that during the war we could have used three times as many physicists as were available in the country and twice as many chemists. Dr. Watson Davis, Director of Science Service, in analyzing the report of Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, entitled "Science, the Endless Frontier" states: "Studies have shown that our deficit of science and technology students, who but for the war, would have received bachelor's degrees is about 150,000. The deficit of those holding advanced degrees, that is, young scholars trained to the point where they are capable of carrying on original work, has been estimated as amounting to about 17,000 by 1955 in chemistry, engineering, geology, mathematics, physics, psychology, and the biological sciences. With mounting demands for scientists both for teaching and research, it becomes obvious that the Nation enters the post war period with a serious deficit in its trained scientific personnel."

The convention will be high-lighted by Gerald Wendt, Editorial Director of *Science Illustrated*, who, in his opening remarks will emphasize each aspect of the convention theme, "New Power, Products, and Personnel." Other speakers on the general program will pursue each of these aspects in greater detail. These speakers will include: T. H. Davis of Northwestern University; Watson Davis, Director of *Science Service;* and Frederick L. Hovde, President of Purdue University.

At the Friday luncheon meeting the General Motors Corporation will correlate their new floor show with the PRODUCTS aspects of this convention theme. Through the section and group meetings further interpretations of the convention theme, will take place through such speeches as:

"A Chemist Looks at the Manufacture and Control of Pharmaceuticals"
"Coal Tar Products in World War II"
"Application of Statistical Methods to Modern Research"

"Technological Advances in Plastics and Rubber"
"Food Supply for Today's and Tomorrow's People"
"An Overview of a Meaningful Program in Arithmetic"
"Forests for Human Welfare"
"Maps of National Power"
"What the Economist Believes the Scientist and Mathematician Can Contribute to Living Today"
"Matching People and Jobs"
"Mathematics in Junior High School"

Of great interest to all members is the fact that the annual banquet, which was given up during the war period, will be restored again. It will be equally gratifying for all of us to know that Dr. J. O. Perrine of the American Telephone and Telegraph Corporation will be with us again for this occasion. Many members will recall how delightful the Friday evening banquets have been in the past because of the presence of such outstanding speakers of the country as Dr. Perrine. This year he will present his new address "Radar and Micro-waves."

Finally, everyone will want to participate in the new feature that is being inaugurated in connection with this coming convention—a free Saturday afternoon trip! This year members will be treated to a free luncheon while enroute on special buses to visit the River Rouge Plant, Greenfield Village, and the Edison Institute Museum. At the Edison Institute Museum theater, Mr. Carroll and Mr. James will address visitors on "What Ford Engineers Are Thinking About for the Future."

YOUR DREAM CAR OF TOMORROW! YOUR DREAM HOME OF TOMORROW! AND YOUR MANY OTHER DREAMS OF TOMORROW!

will be seen to be realistically approaching soon if you will hear the interpretations that will be given at this coming convention to "New Power, Products, and Personnel" and the impacts of these upon living as it mav be experienced in the near future.

EMERITUS LIFE MEMBERSHIPS

At the spring meeting of the Board of Directors of the Association, held at Detroit on Saturday, May 11, it was unanimously voted to establish Emeritus Life Memberships. According to the motion establishing these memberships, a member is eligible for emeritus status if he has been in continuous membership for a period of 25 years and has retired from active teaching. Emeritus membership will carry all the privileges of regular membership including convention attendance and subscription to SCHOOL SCIENCE AND MATHEMATICS. It will continue in effect for the life of the recipient with no cost to him. Presentation of the memberships will be made as a part of the Friday morning general session of the annual Convention. It is apparent that the Association, in honoring these men and women who have given many years to the teaching of Science and Mathematics and to the affairs of the Association, will also be honoring itself.

Members can be of help in making this project a success if they will report to our Business Manager, Mr. Ray C. Soliday, Box 408, Oak Park, Illinois, the names of people they think are eligible for this type of membership.

GEO. K. PETERSON, Chairman
Journal Committee

AN INVITATION TO CONTRIBUTE TOWARD THE REHABILITATION OF DEVASTATED LIBRARIES

During the war, libraries of half the world were destroyed in the fires of battle and in the fires of hate and fanaticism. There is urgent need—now—for the printed materials which are basic to the reconstruction of devastated areas and which can help remove the intellectual blackout of Europe and the Orient.

There is need for a pooling of resources, for coordinated action in order that the devastated libraries of the world may be restocked as far as possible with needed American publications. Through the combined efforts of library and educational organizations, of government agencies, and many other official and non-official bodies of the United States, The American Book Center for War Devastated Libraries, Inc. has come into being to meet this need. This agency is collecting and shipping abroad scholarly books and periodicals which will be useful in research and in the physical, economic, social and industrial rehabilitation and reconstruction of Europe and the Far East. The Center cannot purchase books or periodicals; it must depend upon gifts from individuals, institutions and organizations.

This program is one which will have the interest of the entire scholarly and educational world. The Central Association of Science and Mathematics Teachers considers this a most worthy project, and invites all members and others to cooperate to the maximum possible extent. It is believed that this office may be of considerable service to the Book Center by consolidating small contributions from many individuals into complete volumes or sets, and shipping them in larger quantities to Washington. The undersigned will donate time and space for sorting, combining, classifying and packaging, and the Central Association will pay shipping costs from River Forest to Washington.

What Is Needed: Publications issued during the past decade, scholarly books which are important contributions to their fields, periodicals (even incomplete volumes) of significance, fiction and non-fiction of distinction. All subjects—history, the social sciences, music, fine arts, literature, and especially the sciences and technologies—are wanted. It seems probable that Central Association members and other subscribers to SCHOOL SCIENCE AND MATHEMATICS have many back numbers of this journal and other scientific periodicals, as well as scholarly books in the scientific and mathematical fields which would be appropriate.

What Is Not Needed: Textbooks, out-dated monographs, recreational reading, books for children and young people, light fiction, materials of purely local interest, popular magazines such as *Time*, *Life*, *National Geographic*, etc., popular fiction of little enduring significance, such as Gunther's *Inside Europe*, Haliburton's *Royal Road to Romance*, etc. Only carefully selected federal and local documents are needed.

How to Ship: We invite all our members and readers to send all contributions large or small, to BOOK CENTER, c/o SCHOOL SCIENCE AND MATHEMATICS, 144 Forest Ave., River Forest, Illinois, *PREPAID.* Those who definitely prefer, especially readers in the East, or those with large donations, may ship direct to the American Book Center, c/o The Library of Congress, Washington 25, D. C.

This office will not attempt to acknowledge all contributions. However, a record of all receipts will be kept and transmitted to the American Book Center. It is anticipated that a report of this Central Association project, with a listing of all contributors, will appear in SCHOOL SCIENCE AND MATHEMATICS.

RAY C. SOLIDAY, Business Manager,
SCHOOL SCIENCE AND MATHEMATICS

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1973. *Hazel S. Wilson, Annapolis, Md.*

1965. *L. R. Galebaugh, Palmyra, Md.*

1970. 2. *Henry Silverman, Brooklyn, N. Y.*

A Late Solution

1913. *Proposed by Helen M. Scott, Baltimore, Md.*

Two circular cylinders intersect so that their axes form an angle of 45°. If the diameter of one is 2 inches, and the other 1 inch, find the volume common to both.

Solution by Francis L. Miksa, Aurora, Ill.

In attached figure (1) is shown the intersection in perspective for two, quarter-cylinders, C_1 and C_2 one of radius 'R,' and other of radius 'a,' with their axes inclined at angle α.

In the projection of cross section of cylinder C_1 on the xy plane, the values of '$x' = op$ will remain unchanged so that

$$OP = O'P' = E'M = x \tag{1}$$

However

$$AB = \frac{A'B'}{\sin\alpha} = \frac{2\sqrt{a^2 - x^2}}{\sin\alpha} = CD. \tag{2}$$

The element of volume common to both cylinders is the slice with base $ABDC$, which is parallel to yz plane.

Thus,

$$dv=\overline{AB}\cdot h\cdot dx. \tag{3}$$

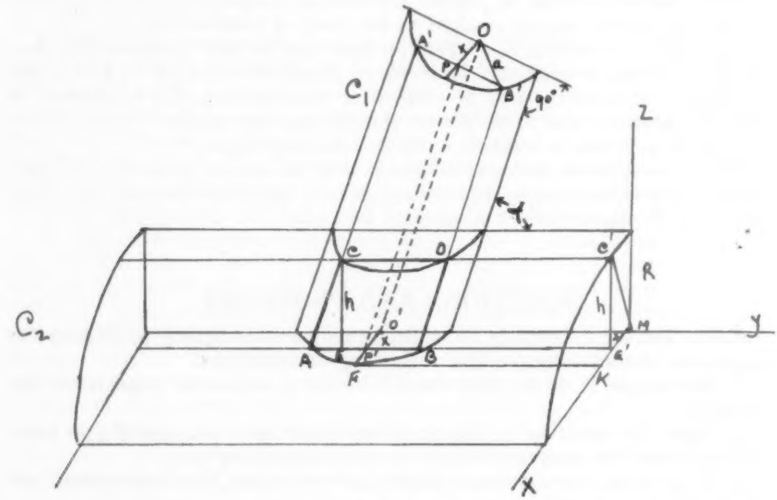


FIG. 1.

From Fig. (1)

$$h=CE\equiv C'E'+\sqrt{R^2-x^2} \tag{4}$$

$$dv=\frac{2\sqrt{a^2-x^2}}{\sin\alpha}\sqrt{R^2-x^2}\,dx \tag{5}$$

total volume is

$$V=\frac{2\cdot 4}{\sin\alpha}\int_0^a\sqrt{a^2-x^2}\,\sqrt{R^2-x^2}\,dx. \tag{6}$$

Now make the following substitution

$$x=a\sin\theta \qquad \therefore\quad dx=a\cos\theta d\theta \tag{7}$$

$$\sqrt{a^2-x^2}=a\cos\theta \tag{8}$$

$$\sqrt{R^2-x^2}=R\sqrt{1-\frac{a^2}{R^2}\sin^2\theta}=R(1-K^2\sin^2\theta)^{1/2} \tag{9}$$

where $K=a/R$. New limits will be $\theta=\pi/2$ and $\theta=0$.

Total volume will be

$$V=\frac{8Ra^2}{\sin\alpha}\int_0^{\pi/2}(1-K^2\sin^2\theta)^{1/2}\cos^2\theta d\theta \tag{10}$$

the solution of (10) involves elliptic integrals. Omitting some of the transformations we get

$$V=\frac{8a^2R}{\sin\theta}\left[\frac{(1+K^2)}{3K^2}E(K,\pi/2)-\frac{(1-K^2)}{3K^2}F(K,\pi/2)\right] \qquad (11$$

where F, and E, are complete elliptic integrals of first and second kind.
The solution of (10) is also given in Bieren's De Haan's "Nouvelles Tables Integrales De Finies," Page 84, Table 53, Integral 7.

Now in this specific case

$$a=\tfrac{1}{2} \qquad R=1 \qquad \theta=45^\circ \qquad K=\tfrac{1}{2}.$$

Putting these values in eleven we get

$$V=2\sqrt{2}\left[\frac{5E}{3}-F\right]. \tag{12}$$

From tables of elliptic integrals. For $k=\frac{1}{2}$ we get

$$\frac{5E}{3}=2.445770$$

$$-F=1.685750$$

$$\frac{5E}{3}-F=0.760020$$

$$V=2\sqrt{2}\times 0.760020=2.1496609 \text{ cu. in.}$$

Editor's note: Mr. Miksa also offered another solution, using series for $\sqrt{1-x}$ and $\sqrt{1-K^2\sin^2\theta}$, arriving at the same answer.

A solution was also offered by the professor.

1975. *Proposed by W. A. Wallace, St. Paul Minn.*

If N is any odd integer, the square of any multiple of N is the sum of N consecutive integers.

Solution by Martin Pearl, Brooklyn, N. Y.

Let $N=2n+1$. Also let $S(2n+1)$ be any multiple of N.
Hence $S^2(2n+1)^2$ is the square of any multiple of N.
If t is the first term of N consecutive integers,

$$\text{the sum}=t+(t+1)+(t+2)+\cdots \text{ to } N \text{ terms}=(2n+1)(t+n).$$

Hence

$$s^2(2n+1)^2=(2n+1)(t+n)$$

or

$$t=s^2(2n+1)-n,$$

which is an integer.

Solutions were also offered by Samuel M. Berg, Chicago; Alan Wayne, Flushing, L. I.; M. Kirk, Media, Pa.; C. W. Trigg, Los Angeles City College; Helen M. Scott, Baltimore, Md.; Francis L. Miksa, Aurora, Ill.; R. J. Hoyle, Turlock, Calif.; D. F. Wallace, St. Paul Minn.; and the proposer.

1976. *Proposed by Mary Holden, Jennings, Mo.*

If four tangents to a circle determine a harmonic range on a fifth tangent, they determine a harmonic range on every other tangent.

Solution by Hugo Brandt, Chicago

On a circle M with radius $MO=1$ (the size being immaterial), let A and B be 2 points of the circumference. Determine a third point C so that the points, P_a, P_b, P_c, where the 3 tangents AP_a, BP_b, CP_c intersect tangent OP_c, form a harmonic range with O. So then:

$$\frac{OP_a}{P_aP_b}=\frac{OP_c}{P_cP_b}. \tag{1}$$

Call $\sphericalangle\sphericalangle OMA=2\alpha$; $OMB=2\beta$; $OMC=2\gamma$.

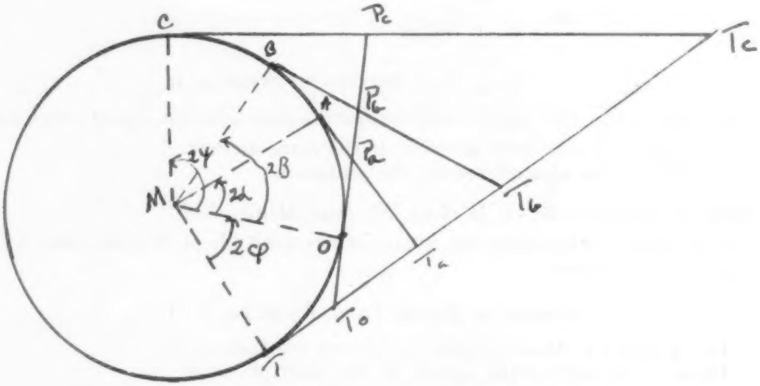
Then $OP_a=\tan\alpha=a$; $OP_b=\tan\beta=b$; $OP_c=\tan\gamma=c$, inserted in (1) we get the relationship

$$\frac{a}{b-a}=\frac{c}{c-b} \tag{2}$$

from which

$$2ac=b(a+c);\quad \frac{2}{b}=\frac{1}{a}+\frac{1}{c}\quad \text{or}\quad 2\cot\beta=\cot\alpha+\cot\gamma. \tag{3}$$

3 determines γ and point C.



We now claim that the 4 tangents: I(P_cO), II(AP_a), III(BP_3), IV (CP_c) are a set that determines a harmonic range on any other tangent. Let such a fifth tangent be at $T_1\perp TM$, where $\sphericalangle OMT=2\phi$, an arbitrary angle, its intersections with I, II, III, IV, being T_0, T_a, T_b, T_c.

$$TT_0=\tan\phi=x,\quad TT_a=\tan(\alpha+\phi)=\frac{a+x}{1-ax};\qquad TT_b=\tan(\beta+\phi)=\frac{b+x}{1-bx};$$

$$TT_c=\frac{c+x}{1-cx}.$$

We must show that $T_0T_aT_bT_c$ = a harmonic range, or

$$\frac{T_0T_a}{T_aT_b}=\frac{T_0T_c}{T_bT_c}\quad\text{or}\quad \frac{\dfrac{a+x}{1-ax}-x}{\dfrac{b+x}{1-bx}-\dfrac{a+x}{1-ax}}=\frac{\dfrac{c-x}{1-cx}-x}{\dfrac{c+x}{1-cx}-\dfrac{b+x}{1-bx}}$$

which reduces to

$$\frac{a}{b-a}=\frac{c}{c-b}.$$

This condition is: 1), independent of x, or the arbitrary angle 2ϕ, hence sufficient for *any* tangent and 2), identical with (2) above and proves

the contention that the set of tangents I, II, III, IV, determine a harmonic range on any other tangent.

Other solutions were offered by V. C. Bailey, Delaware Ohio; Abraham L. Epstein, New York City; Helen M. Scott, Baltimore, Md.

1977. *Proposed by J. F. Cirena, Boone, N. C.*

Find the derivative of $x \sin x$ with respect to $\tan x$

Solution by Hazel S. Wilson, Annapolis, Md.

Set $y = \tan x$. Then

$$\frac{dy}{dx} = \sec^2 x, \quad \text{and} \quad \frac{dx}{dy} = \cos^2 x.$$

Let $x \sin x = \phi$. Then

$$\frac{du}{dy} = \frac{du}{dx} \cdot \frac{dx}{dy}$$

$$\frac{u}{dy} = (x \cos x + \sin x) \cos^2 x$$

$$= x \cos^3 x + \sin x \cos^2 x.$$

Solutions were also offered by V. C. Bailey, Delaware, Ohio; C. W. Trigg, Los Angeles City College; Leslie Axelrod, St. Louis, Mo.; M. Kirk, Media, Pa.; Alan Wayne, Flushing, L. I., New York, N. Y.; Helen M. Scott, Baltimore, Md.

1978. *Proposed by J. F. Arena, Boone, N. C.*

If x is a proper fraction show that

$$\frac{x}{1-x^2} - \frac{x^3}{1-x^6} + \frac{x^5}{1-x^{10}} - \cdots = \frac{x}{1+x^2} + \frac{x^3}{1+x^6} + \frac{x^5}{1-x^{10}} + \cdots.$$

Solution by C. W. Trigg, Los Angeles City College

Since $0 < x < 1$, each fraction may be expressed as a convergent infinite series by dividing the denominator into the corresponding numerator. When these series from the left-hand member are written in rows, the following array is secured:

$$\begin{array}{l} x + x^3 + x^5 + x^7 + \cdots \\ -x^3 - x^9 - x^{15} - x^{21} - \cdots \\ x^5 + x^{15} + x^{25} + x^{35} + \cdots \\ -x^7 - x^{21} - x^{35} - x^{49} - \cdots \\ \cdots\cdots\cdots \quad \cdots \end{array}$$

This same convergent double series is produced by writing the series from the right-hand member in columns. The convergence of the series may be shown by applying the conventional ratio test to each member. Hence it will have the same sum when summed by columns or rows, so the equality holds.

Solutions were also offered by Francis L. Miksa, Aurora, Ill.; Hugo Brand, Chicago; and the proposer.

1979. *Proposed by J. F. Arena, Boone, N. C.*

Find the value of the infinite product: $3^{1/3}\cdot 9^{1/9}\cdot 27^{1/27}\ldots$

Solution by the proposer

The given expression may be written in the form

$$3^{1/3}\cdot 3^{2/9}\cdot 3^{3/27}\ldots$$

or

$$3^{(1/3+2/9+3/27+\cdots)}$$

Let

$$S=\frac{1}{3}+\frac{2}{3^2}+\frac{3}{3^3}+\cdots\frac{n}{3^n}+\cdots$$

then

$$\frac{1}{3}S=\qquad\frac{1}{3^2}+\frac{2}{3^3}+\cdots+\frac{n-1}{3^n}+\cdots$$

$$\therefore\quad\left(1-\frac{1}{3}\right)S=\frac{1}{3}+\frac{1}{3^2}+\frac{1}{3^3}+\cdots+\frac{1}{3^n}+\cdots$$

$$\frac{2}{3}S=\frac{\frac{1}{3}}{1-\frac{1}{3}}=\frac{1}{2}$$

$$S=\frac{3}{4}$$

$$\therefore\quad 3^{1/3}\cdot 9^{1/9}\cdot 27^{1/27}\cdot 81^{1/81}\ldots=3^{3/4}.$$

Solutions were also offered by Charles W. Trigg, Los Angeles City College; Francis L. Miksa, Aurora, Ill.; M. Kirk, Media, Pa.

1980. *Proposed by Brother Felix John, Philadelphia, Pa.*

In a shooting competition a man can score 5, 4, 3, 2, 0 points for each shot. Find the number of different ways in which he can score 30 in 7 shots.

Solution by C. W. Trigg, Los Angeles City College

Possible point sets to score 30	*Permutations of each set*	
5 5 5 5 5 5 0	7	$=7$
5 5 5 5 5 3 2	$7\cdot 6$	$=42$
5 5 5 5 4 4 2	$7\cdot 6\cdot 5/1/2$	$=105$
5 5 5 5 4 3 3	$7\cdot 6\cdot 5/1\cdot 2$	$=105$
5 5 5 4 4 4 3	$7\cdot 6\cdot 5\cdot 4/1\cdot 2\cdot 3$	$=140$
5 5 4 4 4 4 4	$7\cdot 6/1\cdot 2$	$=21$

Hence there are 6 possible "30-targets" which could have been made in 420 ways.

Solutions were also offered by W. R. Smith, Sutton's Bay, Wis.; Helen M. Scott, Baltimore, Md.; V. C. Bailey, Delaware, Ohio; M. Kirk, Media, Pa.; Francis L. Miksa, Aurora, Ill.; and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

1975. Tom Swihart, Elkhart, Ind.; H. E. Trotter, Upper Canada College, Toronto; Henry Silverman, Brooklyn, N. Y.

PROBLEMS FOR SOLUTION

1993. *Proposed by Hugo Brandt, Chicago.*

Find an expression for the sum of the series:

$$S=x+\frac{x^3\cdot 5}{1!8}+\frac{x^5\cdot 7\cdot 9}{2!\cdot 8^2}+\frac{x^7\cdot 9\cdot 11\cdot 13}{3!\cdot 8^3}+\cdots$$

and evaluate it for $x=.96$.

1994. *Proposed by Walter R. Warne, Columbia, Mo.*

Solve the system:

$$x^3+y^3+z^3=3$$
$$x^5+y^5+z^5=3$$
$$x^7+y^7+z^7=3$$

1995. *Proposed by Ollie Raeder, Fayette, N. Y.*

The sides of a triangle are proportional to 3, 4 and 5. If the altitude to the longest side is 48, find the area.

1996. *Proposed by Lucy Reigle, Sampson, N. Y.*

Two chords of a circle meet at right angles. Show that the sum of the four circles drawn on the four segments of the chords as diameters is equal to the area of the given circle.

1997. *Proposed by Hugo Brandt, Chicago.*

In any triangle ABC, if AD is the bisector of A, with D on BC, and if points T and K divide DA so that $DT:TK:KA=a:b:c$, then T is the incenter.

1998. *Proposed by Grace Smith, McDuffietown, N. Y.*

Divide 316 into two parts so that one part is divisible by 13 and the other part by 11.

GOOD EDUCATION—GOOD BUSINESS

There are thousands of us who can honestly proclaim that what we are or what we hope to be we owe to our teachers as well as our parents.

Owe our teachers? The debt of America to the profession of education is astronomical. But for a number of years, it seems to me, we didn't even acknowledge that debt, much less make any effort to pay it.

I think times have changed. I truly believe that there is more interest being shown in education by laymen today than ever before. We in business sense that. Business is learning and learning fast that education is good investment.

ERIC A. JOHNSTON, President
Chamber of Commerce of the United States

BOOKS AND PAMPHLETS RECEIVED

Chemistry and Human Affairs, by William E. Price, Department of Chemistry, Clifford J. Scott High School, East Orange, New Jersey, and George H. Bruce, Late of Horace Mann School for Boys, Teachers College, Columbia University, New York. Cloth. Pages xii+788. 14.5×22.5 cm. 1946. World Book Company, Yonkers-on-Hudson, N. Y. Price $2.68.

The Wonderworld of Science, Book Nine, by Morris Meister, Ralph E. Kierstead, Lois M. Shoemaker. Cloth. Pages vi+698. 13×19.5 cm. 1946. Charles Scribner's Sons, 597 Fifth Avenue, New York, N. Y. Price $2.20.

Mathematics of Investment with Tables, by William L. Hart, Professor of Mathematics, University of Minnesota. Third Edition. Cloth. Pages vi+304+126. 14×21.5 cm. 1946. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $3.60.

Essentials of Plane and Spherical Trigonometry, by Clifford Bell, University of California, Los Angeles, and Tracy Y. Thomas, Indiana University. Revised Edition. Cloth. Pages ix+163. 13.5×21.5 cm. 1946. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, N. Y. Price $2.00, with Tables $2.30.

Biology for You, by B. B. Vance, Chairman, The Science Department, Kiser High School, and Assistant Professor of Biology and Education, The University of Dayton, Dayton, Ohio; D. F. Miller, Professor of Zoology, Supervisor of Teacher Training in Biological Sciences, The Ohio State University, Columbus, Ohio; in Consultation with W. R. Teeters, Director of Education, St. Louis Public Schools, St. Louis, Mo. Cloth. Pages vii+731. 14.5×22.5 cm. 1946. J. B. Lippincott Company, 333 W. Lake Street, Chicago 6, Ill. Price $2.28.

Science for Everyday Use, by Victor C. Smith, Department of General Science, Ramsey Junior High School, Minneapolis, Minnesota; B. B. Vance, Chairman, Science Department, Kiser High School, Assistant Professor of Biology and Education, The University of Dayton, Dayton, Ohio; in Consultation with W. R. Teeters, Director of Education, St. Louis Public Schools, St. Louis, Mo. Cloth. Pages xiii+731. 14.5×22.5 cm. 1946. J. B. Lippincott Company, 333 W. Lake Street, Chicago 6, Ill. Price $1.96.

College Mathematics, A General Introduction, by Charles H. Sisam, Professor of Mathematics, Colorado College, Colorado Springs, Colo. Cloth. Pages xiii+561. 15×23.5 cm. 1946. Henry Holt and Company Inc., 257 Fourth Avenue, New York 10, N. Y. Price $3.50.

Introduction to Atomic Physics, by Henry Semat, Ph.D., Associate Professor of Physics, The City College, College of the City of New York. Revised and Enlarged. Cloth. Pages xi+412. 15×23 cm. 1946. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $4.50.

Soul of Lodestone, by Alfred Still, Fellow, American Institute of Electrical Engineers; Member, Institution of Electrical Engineers (London). A Companion Volume to *Soul of Amber*. Cloth. Pages x+233. 14×21 cm. 1946. Murray Hill Books, Inc., 232 Madison Avenue, New York 16, N. Y. Price $2.50.

Physics, by Walter G. Whitman, Formerly Head, Physical Science Department, State Teachers College, Salem, Massachusetts; and A. P. Peck, Managing Editor, Scientific American, New York, N. Y. Cloth. Pages viii +629. 15×22 cm. 1946. American Book Company, 88 Lexington Avenue, New York 16, N. Y. Price $3.00.

Mathematics in Life; Basic Course, by Raleigh Schorling, Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan; and John R. Clark, Professor of Education, Teachers College, Columbia University. Cloth. Pages xii +500. 15×24 cm. 1946. World Book Company, Yonkers-on-Hudson 5, N. Y. Price $1.80.

Circuit Analysis by Laboratory Methods, by Carl E. Skroder, Associate Professor of Electrical Engineering, University of Illinois, and M. Stanley Helm, Assistant Professor of Electrical Engineering, University of Illinois. Cloth. Pages xvi +288. 15×23 cm. 1946. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.35.

Coyotes, by Wilfrid S. Bronson. Cloth. 57 pages. 16×20.5 cm. 1946. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N.Y. Price $1.75.

Vitalized Chemistry, by Russell T. Des Jardins, Department of Chemistry, Pierre S. Du Pont High School, Wilmington, Delaware. Edited by George C. Job, Departmental Supervisor of Science Public Schools, Albany New York; and Theodore C. Sargent, High School, Swampscott, Massachusetts and President, New England Association of Chemistry Teachers. Revised Edition. Paper. Pages iv +366. 12.5×18.5 cm. 1946. College Entrance Book Company, 104 Fifth Avenue, New York 11, N. Y. Price 65 cents.

Vitalized Physics, by Robert H. Carleton, Head of Department of Science, Summit High School, Summit, N. Y. Edited by Michael N. Idelson, Head of the Department of Physical Sciences, Abraham Lincoln High School, Brooklyn, New York. Revised Edition. Paper. Pages ii +378 +iv. 12.5×18.5 cm. 1946. College Entrance Book Company, 104 Fifth Avenue, New York 11, N. Y. Price 65 cents.

The Development of Trigonometry from Regiomontanus to Pitiscus, by Sister Mary Claudia Zeller of the Sisters of St. Francis of Mary Immaculate, Joliet, Illinois. Paper. Pages vi +119. 21×27.5 cm. 1946. Sister Mary Claudia Zeller, Joliet, Ill.

Laboratory Manual in Engineering Physics, by Frederick L. Brown, Rouss Physical Laboratory, University of Virginia. Paper. 28 Experiments. 21×28 cm. 1946. Charlottesville, Va.

Elementary Teachers Guide to Free Curriculum Materials. Edited by John Guy Fowlkes, Ph.D., Professor of Education and Dean of Summer Session, University of Wisconsin; and Donald A. Morgan, M. A., Supervising Principal, Randolph Public Schools, Randolph, Wisconsin. Third Edition. Revised August, 1946. Paper. 204 pages. 20×27.5 cm. Educators Progress Service, Box 497, Randolph, Wis. Price $3.50.

Bullets by the Billion, by Wesley W. Stout, former Editor of the Saturday Evening Post. Cloth. 77 pages. 12.5×20 cm. 1946. Chrysler Corporation, Detroit, Mich.

THE RADIO AMATEUR'S HANDBOOK, by the Headquarters Staff of th American Radio Relay League. Twenty-Third Edition. Paper. 688 pages 16.5×24 cm. 1946. The American Radio Relay League, West Hartford 7 Conn. Price, $1.00 in U.S.A., $1.50 elsewhere.

SCIENCE; AN APPROACH IN THE ELEMENTARY SCHOOL, by Ralph C. Preston, Associate Professor of Education, University of Pennsylvania, Philadelphia, Pa. Paper. 39 pages. 15×23 cm. 1945. Price 40 cents.

THE FORTY-FIFTH YEARBOOK OF THE NATIONAL SOCIETY FOR THE STUDY OF EDUCATION. PART I, THE MEASUREMENT OF UNDERSTANDING, Prepared by the Society's Committee. William A. Brownell, Chairman. Paper. Pages xi+338+v. 14.5×22 cm. 1946. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Ill. Price $2.25.

MATHEMATICIAN'S DELIGHT, by W. W. Sawyer, Assistant Lecturer in Mathematics, Manchester University, Manchester, England. Paper. 224 pages. 10.5×18 cm. 1946. Penguin Books, Inc., 245 Fifth Avenue, New York, N. Y. Price 25 cents.

DEVELOPING NUMBER READINESS. Guidebook for the Number Readines Chart, by Anita Riess and Maurice Hartung. Paper. 36 pages, 22×24 cm. 1946. Scott, Foresman and Company, Chicago, Ill.

TENTH ANNUAL REPORT OF HUNTINGTON COLLEGE BOTANICAL GARDEN AND ARBORETUM, by Fred A. Loew, Director, and Head of the Department of Biology. Paper. 52 pages. 13.5×21.5 cm. December 1945. Huntington College, Huntington, Ind.

THE VETERAN AND HIGHER EDUCATION. A REPORT TO THE PRESIDENT, BY THE DIRECTOR OF WAR MOBILIZATION AND RECONVERSION. May 20, 1946. Paper. Pages v+39. 15×23 cm. Office of War Mobilization and Reconversion, Washington, D. C.

VOCATIONAL EDUCATION IN THE YEARS AHEAD. A REPORT OF A COMMITTEE TO STUDY POSTWAR PROBLEMS IN VOCATIONAL EDUCATION. Paper Pages xiv+329. 14×23.5 cm. 1945. Superintendent of Documents, Washington 25, D. C. Price 50 cents.

FIRES THAT NEVER HAPPENED. Paper. 42 pages. 15×23 cm. Published by The National Board of Fire Underwriters, 85 John Street, New York, 7 N. Y.

EDUCATION IN PERU, by Cameron D. Ebauch, Senior Specialist on Education in Latin American Countries, Division of Comparative Education. Bulletin 1946, No. 3. Pages vii+91. 14×23 cm. Superintendent of Documents, Washington 25, D. C. Price 20 cents.

CURRICULUM ADJUSTMENTS FOR GIFTED CHILDREN, by Elise H. Martens, Senior Specialist in the Education of Exceptional Children, U. S. Office of Education with Collaboration of Teachers, Supervisors, Administrators and Guidance Specialists. Bulletin 1946, No. 1. Pages vi+82. 14.5×23 cm. Superintendent of Documents, Washington 25, D. C. Price 20 cents.

LESSONS IN SCIENCE SERIES FOR SCHOOL AND HOME STUDY. Number One: The Story of the Thermometer, by Benjamin De Leon, Science Department, South Side High School, Newark, New Jersey. Paper. 32 pages. 15.5×23.5 cm. 1946. Science Learning Aids Publishing Company, Box 8085, Clinton Hill Station, Newark 8, N. J.

SHOULD THE GOVERNMENT SUPPORT SCIENCE, by Waldemar Kaempffert, Author of Public Affairs Pamphlet No. 78, The Airplane and Tomorrow's World. Public Affairs Pamphlet No. 119. 32 pages. 13.5×21.5 cm. 1946. Public Affairs Committee, Inc., 30 Rockefeller Plaza, New York 20, N. Y. Price 10 cents.

BOOK REVIEWS

SCIENCE AND SCIENTISTS IN THE NETHERLANDS INDIES, Edited by Pieter Honig, Ph.D., and Frans Verdoorn, Ph.D. Cloth. Pages xxii+491. 17×26 cm. 1945. Board for the Netherlands Indies, Surinam and Curacao, 10 Rockefeller Plaza, New York, N. Y. Price $4.00.

Probably no better description of the contents of this book can be given than the following from the EDITOR'S FOREWORD.

"In this volume, *Science and Scientists in the Netherlands Indies*, we have endeavored to present a picture of the development and status of a number of branches of the natural sciences, pure and applied, in the Netherlands Indies. The period during which this volume was prepared has been darkened by the military occupation of both the Indies and the mother country. This circumstance made it impossible to obtain the degree of collaboration necessary for a really complete history of science in the Netherlands Indies.

"The present work consists of:

1) Original articles, prepared especially for this volume, dealing with the development or status of various branches of science in the Netherlands Indies.
2) Reprints of similar accounts previously published elsewhere, several of which originally appeared in Dutch and are now being made available in English.
3) A number of travel accounts and impressions by distinguished visitors in the past, often offering delightful glimpses (scientific and otherwise) of life and nature in the Netherlands Indies.
4) A number of shorter articles—notes, biographical sketches, reviews, etc. ("Serta Malesiana")—comprising material often of interest from the viewpoint of the promotion of North American-Netherlands Indies relationships.
5) A list of scientific institutions, societies, and workers in the Netherlands Indies at the time of the Japanese invasion."

Now that work has again started to restore this vast territory to normal life the people of the United States have here in one volume a set of well written articles covering many of the important characteristics of this great group of islands and their inhabitants whom we should know. From the heavily populated island of Java to the vast wilderness of Borneo every variation in living conditions can be found, for the climate ranges from the hot steaming jungles at sea level along the equator to the snow covered peaks in the high mountain regions only a few air miles away. It is impossible in a short review to give the reader much about a book of this type, but whether you are a geographer, botanist, mining engineer, student of veterinary science, agriculturalist, astronomer, or any one of a long list of scientists, or merely in search of adventure and discovery, this book will interest you. A few years ago Borneo was so far away it seemed of little interest to most of us. Now it is but a few hours from New York or Chicago. In the next few years many people from the United States will visit the Indies. This book is an excellent place to start: scientific reading, excellent

photographs and maps, places of interest, minerals, grains, live stock, botanical stations, hospitals, colleges, tropical jungles and alpine scenery. Never before so much authentic information for so small a price.

G.W.W.

VOLCANOES NEW AND OLD, by Satis N. Coleman, Author of *Creative Music in the Home*. Cloth. Pages ' ii+222. 15×23.5 cm. 1946. The John Day Company, 2 West 45th Street, New York 19, N. Y. Price $3.75.

This is one of the very unusual books of the year, written by a noted musician who was inspired by a summer trip to see the famous Mexican volcano that grew in an Indian's cornfield. The book contains an unusual collection of wonderful illustrations gleaned from many sources famous for fine photography. In all nearly a hundred beautiful pictures are included. The first chapter of nineteen pages describes El Paricutin, the recent great Mexican exhibit of volcanic activity. Four short chapters follow giving the causes of volcanoes, describing their materials, pointing out their differences and the types and forms of their craters, and giving the general distribution of volcanoes around the world. Then follows sixteen short, interesting chapters describing the principal volcanoes of the world and giving many of the startling incidents and major calamities connected with their eruptions—the loss of life, destruction of property, burial of cities, and complete subsidence of islands below the surface of the sea. The book is attractive in artistic design, intensely interesting in story, especially to those who love the grandeur of natural phenomena and scenery, and highly instructive to those with scientific interests. It is an excellent gift book for anyone.

G.W.W.

MATHEMATICS WE USE. Books I, II, and III, by Leo J. Brueckner, *Professor of Education Administration and Supervision, University of Minnesota;* Foster E. Grassnickle, *Professor of Mathematics, New Jersey State Teachers College, Jersey City.* Book Three has a third author, Fred L. Bedford, *Associate Professor of Mathematics, New Jersey State Teachers College, Jersey City.*

Book One, 305 pages, 15 cm.×20 cm., 1945, f.o.b., $.66. Book Two, 312 pages, 15 cm.×20 cm., 1945, f.o.b., $.99, John C. Winston Company, 623–633 South Wabash Avenue, Chicago 5, Illinois.

This series of books is intended for use in grades 7, 8, and 9. They are the same books that were published in 1942 under the title of "Arithmetic We Use." The new title is much more appropriate because all three texts are general mathematics books. The major emphasis is on arithmetic with meaning and the development of number concepts. The general plan is to introduce topics with questions based upon social factors pupils of that level are familiar with. From this the calculations are made. At intervals throughout the text, there are summaries of what the student must be able to do if he expects to be successful in the work. There are a fair number of problems without values to be used for analysis. Diagnostic tests are given and the pupil is told their purpose so he may be encouraged to improve himself. In Book One, place value and the story of our number system is well developed and reference is made to this in Books Two and Three. Although these books treat social mathematics problems the authors have assured mastery of the necessary processes before introducing the social application. A great deal of work is done with fractions and the meanings are very well established, but cancellation is also introduced when it might

better have been left out. The vocabulary has been carefully selected and appears throughout the texts.

Much emphasis is put on quantitative concepts with practice sets in comparing sizes of decimal fractions, common fractions, et cetera. However, in Book Three, page 60 discusses "Tolerance"; page 61, "Rounding off Numbers," which might lead to confusion, because the first is only measured to that precision, while the second is primarily a means of estimating results. The text has not taken advantage of the opportunity to use the determination of significant digits to aid in teaching meaning and understanding of number. Graphing is very well done with interpretation and reading the important item. The series is written for easy maintenance and all phases of mathematics are carried for the three years. The material on large numbers is a splendid addition to the texts. All three texts contain a large number of practice and written problems with many of them easily adapted to local situations. Use is made of tables such as, square root tables, and practice in their use is given.

The metric system is introduced in Books Two and Three, but not enough material for their use is included to keep the information learned.

Book One reviews the fundamental operations, introduces decimals, graphs, percentage in relation to fractions and decimals, simple geometry, drawing to scale and constructions, measuring areas. The last two chapters deal with mathematics of the home and business. A few applications are given of each major activity, but the conditions are much simplified. Book Two develops the formula using distance, area, et cetera; percentage is used for comparison; graphs, both making and reading; phases of handling money, such as investment, insurance, and installment buying cover 76 pages; taxes, geometry, volumes, measurement, ratios, indirect measure. There are a few pages at the close of the book on the equation. Book Three treats arithmetic with applications to graphs and geometry in the first 80 pages. The formula introduces the equations and pages 81–138 deal with all types of simple equations in one unknown. This algebra is then used in mathematics of finance, pages 141–188. Geometry of construction and designs, pages 189–216. Directed numbers and applications, pages 217–239. Mensuration including interest, pages 243–311. Insurance and taxes, pages 313–357. The final chapter is considered optional, but takes one through linear systems and variations.

These texts are pleasing to the eye and have many pictures and drawings. They do not assume mastery, but continued practice and review on fundamentals. The placing of emphasis on meaning and understanding is definitely a step in the right direction.

PHILIP PEAK
University School,
Bloomington, Indiana

"ALGEBRA—A SECOND COURSE," by R. Orin Cornett, *Harvard University* (on leave from Oklahoma Baptist University, Shawnee, Oklahoma.) McGraw-Hill Book Company, 330 West 42nd. Street, New York City. Pages, xiii+313. 15×22.5 cm. Cloth. 1945. First edition.

The text is intended for pupils who have had one year of algebra in the high school. It has an interesting approach in Chapter I, "Mental Gymnastics," intended to aid the pupil in his study habits, and retention of that material learned. There are questions at the close for practice in this area. Chapter II goes into detail on the algebraic method and does very well in explaining the process of setting up problems. Review of fundamental operations takes up about 7 per cent of the text.

First degree equations and linear systems in two and three unknowns are given in Chapter IV with practice problems. Transposition is introduced on the second page of this chapter.

The next chapter is "Stated Problems," and fair attempt is made at teaching the pupil methods of solving problems. This chapter contains more such material than the reviewer has come across in any other text. The problems are classified as: Investment, Mixture, Mechanics, et cetera.

The reviewer is fond of the statement found on page 76, "Probably the most important of all study habits is that of stopping to think."

"Graphical Methods" are well done with both linear and quadratic equations. The remainder of the text covers the standard material for an advanced course and, for the average class, would provide sufficient material for a year's course.

Chapter XIX is designed to emphasize extraneous roots, et cetera, by puzzle problems and stories.

Throughout the text definitions and important directions are boxed in and in black type. They may appear anywhere on the page. There is a table of square roots, three place log table, and a trigonometric table of sin, cos, and tan, and the logs of the same. Answers are given in the back to the odd number problems, listed by sections and pages. There is a good supply of problems distributed throughout the book.

This is a different book in manner of introduction and in the relationship shown between the various topics. The author has done a very good job of tying the various topics together so one can help the other. It seems to be a definite step in the right direction.

PHILIP PEAK

FIRST PRINCIPLES OF BUSINESS, by Louis A. Rice, *Packard School, New York City;* James H. Dodd, *Mary Washington College, Charlottesville, Virginia;* Augustin L. Casgrove, *University of Oklahoma, Norman, Oklahoma.* Cloth. Pages x+598. 15×22 cm. 1944. D. C. Heath and Company, Chicago, Illinois.

This book is designed as a first course in business for high school students. It is written in general terms and could profitably be used by pupils as a source of information for personal business as well as those of the commercial department. The four general divisions are: 1) The nature and function of business; 2) Communication, transportation, saving and consumer credit, money and credit, insurance, and public service; 3) Activities of business which includes: management, buying, production selling, financing, letter writing, and record keeping; 4) Human relations in business. The book is well filled with authentic business forms and good pictures of actual situations. Each chapter points out how the following chapters will answer some of the questions that are now being met.

There are four types of exercises at the close of each chapter: 1) Short review questions on facts; 2) Thought questions, many of which will require outside information; 3) Laboratory problems, such as making reports, lists, et cetera; 4) Correlated arithmetic, composed of such problems that the business man would meet when carrying on the business of that chapter. A vocabulary is also given. The authors have tried to develop a sound philosophy and give advice on stocks, bonds, installment buying, check writing, et cetera. A small amount of historical material is included to add clarity. There are very few errors for a first edition, and the book is well written. It comes right to the point, is logical, systematic, and thorough. This book will hold the interest of the pupil because it is addressed to him and he is made to feel as a partner in the business.

PHILIP PEAK

SOLID GEOMETRY, by Frank M. Morgan, *Director of Clark School (College Preparatory), Hanover, New Hampshire; Formerly Assistant Professor of Mathematics, Dartmouth College, Hanover, New Hampshire*, and W. E. Breckenridge, *Formerly Head of the Department of Mathematics, Stuyvesant High School, New York City*. Revised Edition. Cloth. Pages viii +330+x. 13.5×19.5 cm. 1946. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.48.

This is a revised edition of an earlier book. The authors state that "the development of Solid Geometry follows the plan of Plane Geometry in its main features." The theorems included in this book and the suggested plans for their solution are the ones usually found in Solid Geometry textbooks. The most important theorems are starred. The exercises are numerous and are of a practical nature. The authors have inserted in the appendix of their book a classification of the various exercises according to difficulty. This index is intended to be used as a guide to the teacher in making assignments for poor, average, or superior students. I like this plan very much. They also have classified the exercises according to geometric method, another good idea.

Other features of this text which are most outstanding are: (1) the introduction, which provides not only for transition in thinking from plane to solid geometry but also for a realization of the importance of perspective in the drawing of three-dimension figures on a plane surface; (2) the use of True-False Tests, Completion Tests, Review Exercises, and Miscellaneous Exercises to provide the additional material which aids in the review of such a course; and (3) the illustrations, which include the usual figures for the theorems and exercises of solid geometry and also other illustrations and drawings which emphasize the place of this subject in our modern world.

Solid Geometry is well presented and I believe has the dual characteristics so necessary in a textbook, material to catch and hold the interest of the pupil and material which can be successfully taught by the teacher.

ALBERT R. MAHIN,
Hartford City High School,
Hartford City, Indiana

LOOKING AHEAD IN EDUCATION, Planned and Edited by J. Wayne Wrightstone, *Board of Education of the City of New York*, and Morris Meister, *High School of Science, Bronx, New York City*. Cloth. Pages xvi+151. 14.5×22 cm. 1945. Ginn and Company, Statler Building, Boston, Mass. Price $1.50.

If there is anyone who doubts that teachers leave their footprints on the sands of time, let him look at this little volume. Here, in twenty-four separate articles, as many authors testify to the influence of a teacher on their lives and thoughts. The fact that this teacher happens to be a professor of experimental education at Columbia makes little difference. The fact of importance is that he is a teacher, and that his students have chosen to show on his 75th anniversary that he influenced their lives and thoughts. Anyone reading this book will be convinced that teaching is not merely transfer of knowledge. It is even more the motivation of students to the end that they acquire, and increase, existing knowledge.

From the depths of their knowledge, from their laboratory resources, from their active and trained imaginations, twenty-four scholars (not all of them teachers but all of them lifelong students) have undertaken the task of predicting future trends in various fields of education. Among predictions of special interest, one must mention those having reference to experimental education, measurement, personality analysis, intelligence

testing, elementary education, rural education, reading, science education, secondary school mathematics, research in music education, and a number of other fields.

It is amazing how much can be put into little space. The articles run to four or five pages on the average, but their organization is such that no space is wasted on preliminaries or off-hand remarks. Each article is factual, specific, practical. Writing with journalistic clarity, each author tries to cover his special problem in as few words as possible. In this most of them succeed admirably indeed.

For a bird's eye-view of what is ahead in education, the reviewer recommends this little volume to any teacher who has a couple of afternoons or a Sunday to spare for profitable professional reading.

MAURICE H. KROUT
Chicago City Junior College

COLLEGE MATHEMATICS, A GENERAL INTRODUCTION, by Charles H. Sisam. *Professor of Mathematics, Colorado College, Colorado Springs, Colo.* Cloth. Pages xiii+561. 15×23.5 cm. 1946. Henry Holt and Company, Inc., 257 Fourth Avenue, New York 10, N. Y. Price $3.50.

This text presents the customary first-year course in college algebra, trigonometry, and analytic geometry, as well as an introduction to the calculus. To quote from the Preface:

"No attempt has been made either to unify or to keep separate the component subjects. What the author has tried to do is to present the entire subject matter in a single natural and orderly sequence. It is believed that the essential interdependence of the separate subjects can best be exhibited in this way."

Starting as it does with a review of elementary algebra, this book is particularly timely when class rooms are crowded with veterans whose algebraic knowledge has not survived their years of war experience.

This book, while it introduces no innovations in material or method of presentation, impresses this reviewer as a very teachable text. The explanations are clear and the theory is illustrated with a wealth of examples. The problems are numerous and well selected. Adequate tables are included. By selecting his material, a teacher may adapt this text to courses of various lengths and to classes which are well or poorly prepared.

HARRY S. POLLARD
Miami University

COLLEGE PHYSICS, by William T. McNiff, *Assistant Professor of Physics' Fordham University.* Third Edition. Second Printing 1943. Cloth. Pages xxi+666. 15×23.5 cm. Fordham University Press, New York, N. Y. Price $4.00.

In this edition the author has combined the two volumes of the previous editions in one and has considerably revised and augmented the material included in the first edition. The text is divided into seven parts under the titles of Mechanics, Heat, Sound, Light, Magnetism, Electricity and a Review of Modern Physics. The material in these parts is divided into forty-nine chapters each of which forms a satisfactory unit. The material in almost all chapters is illustrated with solved type problems and at the end of each chapter a good selection of problems to be solved by the student is available. The answers to these problems appear in the appendix.

In the appendix besides the answers to the problems and an extensive index are to be found a very useful Review of the Fundamentals of Mathematics, Logarithmic and Trigonometric Tables, International Atomic Weights as of 1941, Periodic Table of Elements, Table of Electromagnetic

Waves and a comprehensive index of textbooks of physics and some of the more important journals of reference in physics.

An outstanding characteristic of the book is that although considerable space is devoted to the introduction of the concepts and problems of modern physics no omissions of any consequence were noticed from the topics of classical physics. The author after one chapter on properties of matter and one on the physical units of measurements continues with chapters on mechanics of fluids and related subjects thus postponing the topic of uniformly accelerated motion until chapter eight and the concept of force until chapter nine. Many teachers have found this arrangement very useful, especially with premedical and general liberal arts students.

At this point we must note that much material of special interest to premedical students not to be found in other books, has been introduced in this book, thus, Chapter 8 deals with the psychological and therapeutical effect of changes in air density and the few pages of Chapter 44 deal with electricity as a therapeutic agent.

In perusing the book the writer is left with a definite impression that McNiff's *College Physics* is very well adapted to a course in physics for liberal arts and premedical students and that the book both in respect to selection of material and presentation of it is up-to-date. The drawings and the tables are well-selected to illustrate the subject matter and the exposition of the material is clear and to the point. The spacing of the equations, the use of italics and other devices help to make the reading of this book pleasant and interesting. This new edition can be considered a praiseworthy addition to the existing literature in the field of physics.

PHILIP A. CONSTANTINIDES
Chicago City College

AN INTRODUCTION TO THE SLIDE-RULE, by Harold D. Larsen, Albuquerque. The University of New Mexico Press, 1942. Pp. 20.

This pamphlet offers an excellent introduction to the use of those scales usually found on the student's slide-rule. The discussion of the construction and use of the scales is well related to the theory of logarithms with which it is assumed that the student is familiar. Clear directions, together with sufficient practice material, make this brief treatment of the subject sufficient for the acquisition of skill in the use of the scales considered.

While the placing of the decimal point is, in general, done by means of estimation of the result, it would be entirely feasible for the instructor to introduce the use of numbers in the standard form when the sets of more complicated exercises are reached.

Special mention should be made of the excellent topography so rare in manuals of this type but of such importance to the user. This pamphlet fills a real need for supplementary material for use in high school or college classes in advanced algebra or trigonometry where a working knowledge of the slide-rule, based on the theory of logarithms, is best acquired.

ELSIE PARKER JOHNSON
Oak Park River Forest High School

BIOLOGICAL ABSTRACTS

A new section of *Biological Abstracts* started this year with Volume 20, entitled *Section H—Human Biology*. Ten issues a year plus the comprehensive index issue of the complete edition of *Biological Abstracts* at \$6.00 a year. Foreign \$6.50. Biological Abstracts, University of Pennsylvania, Philadelphia 4, Pa.

A NEW ACCENT FOR THE THREE R'S

The 148 successful candidates selected for the first postwar exchange of teachers between the United States and Great Britain were announced today by John W. Studebaker, U. S. Commissioner of Education.

Boys and girls in 74 schools in this country will hear this fall for the first time accents and pronunciations entirely new to them when they listen to their new teachers from England, Scotland, and Wales. And overseas, British, Welsh, and Scottish children will come in contact with the American language at first-hand as teachers from Maine, Tennessee, California and other States begin work on this new international assignment.

The suggestion for the exchange came to the U. S. Department of State from the British Foreign Office for the Committee on the Interchange of Teachers in Great Britain shortly after V-J Day. Because of the limited time in which to arrange for the first interchange, the Committee for the United States announced the plan to school officials chiefly in cities of 20,000 to 200,000 population and asked for the nomination of teachers. The 74 teachers finally selected from several hundred candidates are representative of all fields of education from nursery school through high school. The same method of selection in Great Britain resulted in 1700 applications from which 74 teachers were chosen.

Each teacher concerned assumes all traveling expenses incident to the transfer from his present post to the new one. Each teacher has been granted a year's leave of absence with pay from the school district in which he is regularly employed.

JOBS IN AIR CONDITIONING SERVICE

Vocational counselors, ex-G.I.'s, students and anyone interested in entering the air conditioning industry as a service and repair man will find helpful information in a new six-page leaflet on employment in this field just published by Occupational Index, Inc., New York University, New York 3, N. Y. Single copies are 25¢, cash with order.

The abstract is entitled *Air Conditioning Service* and covers postwar prospects, nature of the work, unions, qualifications, discrimination, preparation, entrance, advancement, earnings, number and distribution of workers, disadvantages, advantages and an appraisal of the available literature. Selected references for additional reading are included.

JOB INFORMATION

Postwar employment prospects in 6 occupations are described in 6 different six-page Occupational Abstracts just revised and published by Occupational Index, Inc., New York University, New York 3, N. Y., at 25¢ each.

The occupations covered are:

Barber	Electric Lineman
Dentist	General Houseworker
Electrician	Welder

Each abstract summarizes available information on the nature of the work, abilities and training required, earnings, number and distribution of workers, advantages, disadvantages, and postwar prospects. Sources of further information and best references for additional reading are included.